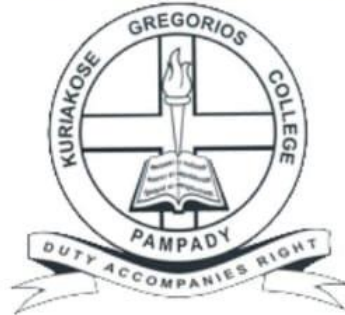


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3.3.1 RESEARCH PAPERS PUBLISHED

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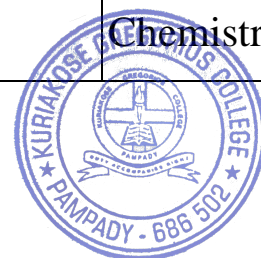
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1	Ek Kavi Ki Shanka	Dr A Priya	Hindi
2	“Vaishveekaran Ka Samay Aur Anupasthith Gaav”	Dr A Priya	Hindi
3	“Bhoomandaleekaran Ke Samay Mein Sthree Asmitha Ke Aayam”	Dr A Priya	Hindi
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15	“Adhivasi Vimarsh Ke Pariprekshy Mein Samakaleen Hindi Kahani”	Dr A Priya	Hindi
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17	A new approach for the shaping up of very fine and beadless UV light absorbing polycarbonate fibers by electrospinning	Dr Thomas Baby	Chemistry



18	Preparation and characterization of luminescent polycarbonate nanofibers embedded with surface capped CdS nanoparticles	Dr Thomas Baby	Chemistry
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22	First principal study of the structural and optoelectronic properties of direct bandgap double perovskite $Cs_2AgInCl_6$	Nishitha P Mathew	Physics
23	Electrospinning technique for the fabrication of poly (styrene-co-methyl methacrylate) nanofibers and the effect of fiber diameter on UV-Visible absorption and thermal properties	Vinitha Varkey	Chemistry



24	A study on the impact of responsible tourism on the economic conditions of home stay owners in Kumarakom	Aleyamma George	Commerce
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29	Inter dependence between work life conflict and family life conflict of the bank employees in Kerala	Vipin K Varughese	Commerce


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कहानियाँ

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अरविंद कलौरस

30 रुपए

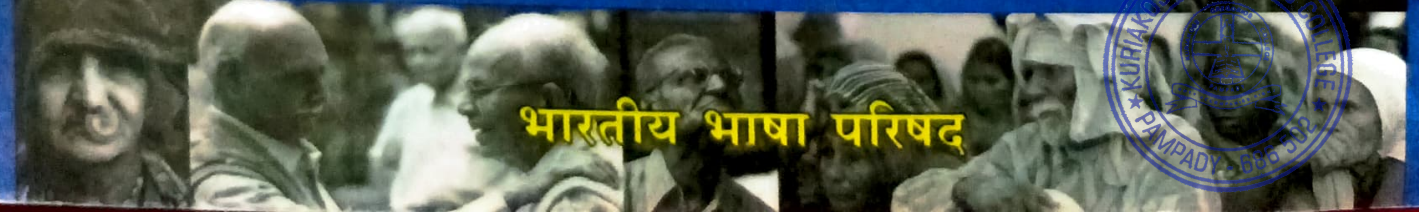
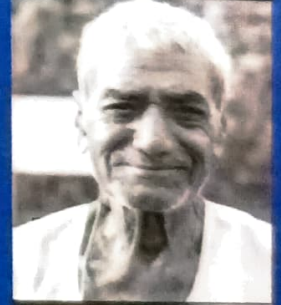
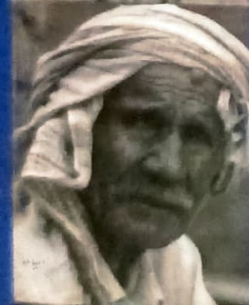
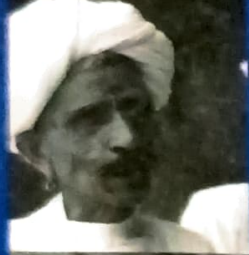
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अंक 288 जुलाई 2019

बुजुर्गों का वर्तमान

गिरिश्वर मिश्र अवधेश प्रसाद सिंह किरण सिंह
हितेन्द्र पटेल राजीव रंजन गिरि रमा शंकर सिंह

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वर्ष 25, अंक 288, जुलाई 2019

संपादक
शंभुनाथ

प्रबंध संपादक
डॉ. कुसुम खेमानी
प्रकाशक
नंदलाल शाह

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तारक नाथ राय

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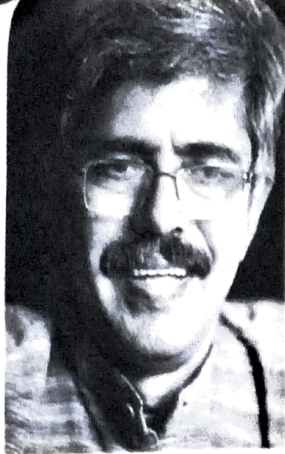
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जन्म : 1957। मलयालम के चर्चित कवि के अलावा फिल्मकार, संगीतकार, अभिनेता तथा अनेक पुरस्कारों से सम्मानित।

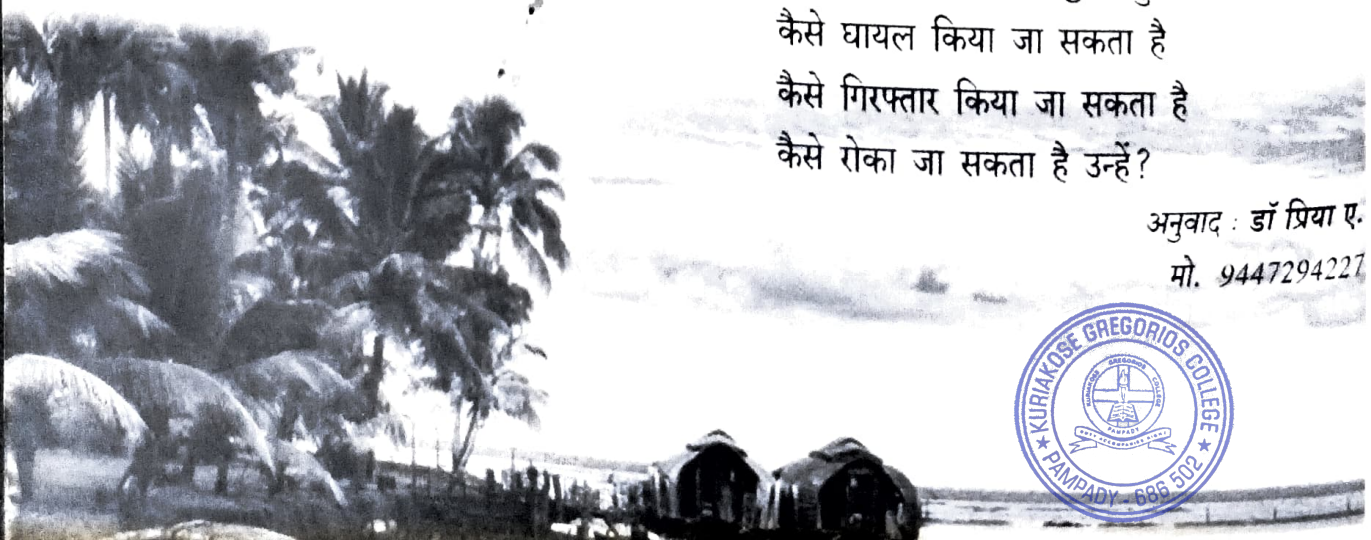
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हमारे पास हथियार तो हैं
 पर नीले गगन को, निर्भय समुद्र को
 ईमानदारी से भरे मन को
 कैसे घायल किया जा सकता है?

हमारे पास हथकड़ियाँ हैं
 पर तूफान को, स्वतंत्रता को
 कैसे गिरफ्तार किया जा सकता है?
 क्या भूकंप से मची हलचल को
 कोई आज्ञा दी जा सकती है?
 रोकने का कठोर आदेश है
 लेकिन कैसे रोका जाए
 सूर्योदय की आभा से भरे स्वप्नों को
 पेड़ों पर झूमते पत्तों को
 गर्भ से निकलते फल को

और साथ मिल कर उत्सव म
 कवियों, किसानों और पक्षियों
 खून के दागों से भरा लोहा है
 और निष्ठुर पत्थर भी हैं
 लेकिन धूप जीवन बिखेर रही
 खेतों और गलियों में
 अदने से अदने आदमी के कंधे पर है सूर्य
 हाथ में हाथ डाल कर चल रही है धूप
 अफसर हैं अधीक्षक हैं
 अधीनस्थ कर्मचारी हैं चपरासी भी हैं
 गुलामी झेलनी पड़ती है
 आदेशों का पालन करना पड़ता है
 आम लोगों को
 उनमें होते हैं साधारण माता-पिता
 छोटे बच्चे, भाई, प्रेमी और दोस्त
 इन सबका है एक ही खून, एक ही सत्य
 एक ही सपना, एक ही स्वतंत्रता
 ये सभी हैं एक जैसी जिंदगी जीने वाले लोग
 प्रेम और दर्द का समान अनुभव करने वाले लोग
 वे हैं धरती की तरह विशाल
 आसमान-सा जिनका खुला हुआ है हृदय
 कैसे घायल किया जा सकता है
 कैसे गिरफ्तार किया जा सकता है
 कैसे रोका जा सकता है उन्हें?

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वैश्वीकरण का समय और अनुपस्थित गाँव

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वैश्वीकरण का समय अनेक संभावनाओं एवं प्रश्नों के साथ हमारे सामने उपस्थित है। वर्तमान समय की विकास प्रक्रिया के कारण हमारे देश में तेज़ी से परिवर्तन आया है। वैश्वीकरण के कारण साँस्कृतिक परिवेश में व्यापक परिवर्तन आए हैं। नव साम्राज्यवादी ताकतों के गिरफ्त में पड़कर मनुष्य दिग्भ्रमित हो रहा है। औद्योगीकरण एवं बाज़ारवादी व्यवस्था ने अर्थतंत्र की प्रधानता को घोषित किया है। इसका प्रभाव समस्त मानव जीवन पर, जीवन के विविध पहलुओं पर दृष्टिपात करता है। समकालीन कवि की अनुभूतियों का संसार अद्भुत है। वे संवेदनशील होने के कारण अपने चारों ओर के बदलते हुए, घुटते हुए मानव जीवन को देखकर अपनी अनुभूतियों को शब्दबद्ध करने लगते हैं। कवि विश्वगाँव में अब अपना गाँव ढूँढ़ रहे हैं। आज के आधुनिकीकरण ने हमारे देश की पहचान को मिटा दिया है। शहरीकरण और व्यवसायीकरण ने पूर्ण रूप से गाँव को तबाह किया है।

प्राचीन समय से गाँव भारतीय सभ्यता और संस्कृति का प्रतीक रहा है। पर विडंबनात्मक सच्चाई यही है कि गाँव अब नहीं रहे। शहरीकरण की सुविधात्मक प्रक्रिया के कारण जनता उसकी लुभावनी दुनिया की ओर आकृष्ट हुई हैं। शहरी वातावरण लोगों पर इस तरह हावी हो गया है कि वे अपने गाँव में असुविधाओं का अनुभव करते हैं। फलस्वरूप गाँव की संस्कृति से दूर होते हुए, शहर को बड़ी दुनिया के रूप में माननेवाली विकल संस्कृति समाज में फैल रही है। इसी तथ्य को पंकज राग अपनी लंबी कविता 'दिल्ली : शहर दर शहर' में उद्घाटित करते हैं - "सुनते हैं कि दिल्ली अब एक फैलता हुआ शहर नहीं दुनिया है / वैसे ही जैसे भारत अब देश नहीं, विश्व हो रहा है।"¹

इन पंक्तियों से ज़ाहिर है कि 'दिल्ली' जैसे महानगरों के तले गाँव की संस्कृति कुचली गयी है। गाँवों का देश भारत अब शहरी दुनिया से व्याप्त विश्व हो गया है।

इक्कीसवीं सदी की कविता खोई हुई गाँवों की संस्कृति को, हमारे देश की विरासत को सुरक्षित रखने की, पुनःप्रतिष्ठित करने की जद्दोजेहद में रत है। ग्राम्य जीवन और लोक संस्कृति के साथ अपनी मिट्टी से, खेत-खलिहानों से एवं पारिस्थितिकी से विलग होने की पीड़ा समकालीन कविता में द्रष्टव्य है। समकालीन कवि एकलाल श्रीवास्तव की एक लंबी कविता है 'नागकेसर का देश यह'। इसमें कवि ने अपने आँचलिक जीवन से जुड़ी काव्ययात्रा को दर्शाया है। आँचलिक जीवन जगत् की कारुणिक दास्तान को यह कविता प्रस्तुत करती है। माँ और बेटे के संवाद द्वारा प्रस्तुत कविता हमारे सम्मुख उपस्थित होती है - "नहीं बेटा, तुम्हारे पिता ने / आँखें मूँदी यहाँ / मेरी मिट्टी भी यहीं उठे / सूख जाने पर भी / पक्षी अपना पेड़ नहीं छोड़ता / तो मैं छोड़ दूँ कैसे अपनी

ISSN - 2455 4839

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INTERNATIONAL JOURNAL OF SOCIAL
SCIENCES AND RESEARCH (IJSSR)

Volume 4, Issue 3A - Sept 2019
(Special Volume)

Proceedings of
National Conference in
Humanities (Hindi)

“भूमंडलीकरण के दौर में हिन्दी एवं अन्य
भारतीय भाषाओं की स्थिति एवं गति”

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Dear Dr. Priya mam

भूमंडलीकरण के दौर में हिन्दी एवं अन्य भारतीय भाषाओं की स्थिति एवं गति

मुख्य संपादक

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भूमंडलीकरण में स्त्री अस्मिता के आयाम

वी. एम. गिरिजा समकालीन मलयालम काव्य जगत की एक प्रमुख कवयित्री हैं। उनका जन्म पालक्काड जिले में षोर्णार के पास परत्तिप्रा नामक गाँव में 1961 को हुआ। संप्रति वे आकाशवाणी कोच्चि एफ.एम स्टेशन में अनौनसर के रूप में कार्यरत हैं। उनके प्रमुख काव्य संकलन हैं - प्रेम एक एलबम, जीवजल, पावयूण, पेण्णुडल काणात्ता पातिरा नेरडल, ओरिडत्तोरिडत्त, इरुपक्षम पेडुमिंदुवल्ला ज्ञान और पूच्युरक्कम। उनको चंगम्पुषा अवार्ड भी प्राप्त हुआ है।

स्त्री सशक्तीकरण एवं स्त्री अस्मिता आजकल एक बहुचर्चित मुद्दा है और महिलाएँ अपनी पूरी क्षमता का एहसास करने की दिशा में अग्रसर हैं। महिला सशक्तीकरण का तात्पर्य है महिलाओं को उनके जीवन एवं कार्यक्षेत्र के संबन्ध में निर्णय लेने का अधिकार होना एवं उन्हें व्यक्तिगत, सामाजिक, आर्थिक, राजनीतिक एवं कानूनी सभी क्षेत्रों में समान अधिकार प्राप्त करना। महिला सुरक्षा के कायदे-कानून होने पर भी स्त्री की सुरक्षा को लेकर हमारे साहित्यकार काफी चिंतित हैं।

वी.एम. गिरिजा का एक अद्यतन काव्य संकलन है - मून्नु दीर्घ कवितकल् (तीन लंबी कविताएँ)। इस काव्य संकलन की तीन सशक्त कविताएँ हैं - अहल्या, कुब्जा और सति। इन कविताओं के तहत कवयित्री ने उत्तराधुनिक समय में स्त्री अस्मिता पर विचार-विमर्श प्रस्तुत किया है। पुराण के तीन स्त्री बिंबों के द्वारा कवयित्री ने स्त्री का उद्धार एवं सशक्तीकरण की वाँछा को अपनी रचनाओं में प्रस्फुटित किया है। महर्षि गौतम के शाप के कारण अहल्या जो सुन्दरी स्त्री थी, वह पाषाण में तब्दील हुई। 'त्रेतायुग' में श्रीराम के चरण-रज से अहल्या को शाप मोक्ष मिला। अहल्या

के शाप ग्रस्तता से लेकर शाप मोक्ष तक की जीवन यात्रा इस कविता में अंकित है।

श्रीराम के आगमन की प्रतीक्षा करती हुई अहल्या पाषाण के रूप में कमजोर एवं निराशा के गर्त में पड़ी हुई थी। प्रताड़न के शिकार होनेवाली स्त्री के प्रति साँत्वना एवं उसके जागरण का आह्वान 'अहल्या' नामक कविता के पहले भाग में देखने को मिलता है।

उन पंक्तियों के माध्यम से कवयित्री का मानना है कि स्त्री का उद्धार पुरुष सत्ता द्वारा ही संभव है। शाप के कारण पत्थर का आकार ग्रहण करनेवाली अहल्या के प्रति कवयित्री की संवेदना यहाँ स्पष्ट हुई है।

कविता के दूसरे भाग में अहल्या का आत्म संवाद तथा अंतर्मन के संघर्ष को प्रस्तुत किया है। पितृसत्तात्मक व्यवस्था स्त्री के खिलाफ है। शोषण, अत्याचार, हिंसा पुरुष की कामुकता एवं वासना के जिरह कवयित्री ने प्रश्नचिह्न लगाकर लिखा है। महिलाओं पर होनेवाले शोषण एवं उत्पीड़न के खिलाफ सशक्तीकरण एक शक्तिशाली औज़ार है। दुर्बल पड़ी अहल्या को राम के द्वारा शक्तिशाली बनने पर भी स्त्री की स्वतंत्रता पर, समावेशी भागीदारी पर कवयित्री ने सवाल उठाया है। 'अहल्या' पुराण का पात्र मात्र न होकर पूरे स्त्री समाज की प्रतिनिधि बनकर हमारे सम्मुख उपस्थित है। वी.एम. गिरिजा की 'कुब्जा' नामक कविता स्त्री के सौंदर्य को स्वतंत्रता में परिवर्तित करने की कोशिश है। 'कुब्जा' जो कंस की नगरी मथुरा में 'कुबड़ी' होने के कारण दासता के, अवस्वतंत्रता के परिवेश में जीवन बिताने के लिए अभिशप्त थी। जब कृष्ण ने उसका उद्धार किया तो वह सुन्दर युवती बन गयी। इस प्रकार अपने रूप सौन्दर्य की प्राप्ति द्वारा वह शोषण से, अस्वतंत्रता से भी मुक्त हुई। प्रस्तुत

कविता में 'कंस' पुरुष वर्चस्ववाद के प्रतीक के रूप में सामने आते हैं। 'कुब्जा' अपनी कुरुपता के कारण कंस के महल में कैदी-सा जीवन बिता रही थी। भगवान कृष्ण ने सौंदर्य का वरदान दिया तो उसके जीवन का स्वरूप ही बदल गया। अतः कुब्जा को जो सौंदर्य प्राप्त हुआ तो वह वास्तव में उसकी स्वतंत्रता की पहली सीढ़ी ही थी। वी.एम. गिरिजा की तीसरी कविता है - सति। इस कविता में शिव और शक्ति के मेल को वर्णित किया है। सति के प्रेम और भक्ति ने शिव के मन को आकृष्ट किया था। पर भरी सभा में अपने पिता दक्ष द्वारा शिव का अपमान हुआ तो सति ने आग में कूदकर अपना देह त्याग किया था। इसके बाद भगवान शिव ने उन्मत्त की तरह सति के जले हुए शरीर को कंधे पर रख लिया और वे सभी दिशाओं में भ्रमण करने लगे। शिव और सति के अलौकिक प्रेम को देखकर पृथ्वी, हवा, जल सभी चराचर स्थगित हो गए। उन पंक्तियों से जाहिर होता है कि कवयित्री ने प्रकृति और पुरुष, शिव और शक्ति के वर्णन के माध्यम से स्त्री और पुरुष की समकक्षता की बात व्यक्त की है। एक के अभाव में दूसरा टिक नहीं सकता। स्त्री के बिना पुरुष का जीवन अधूरा होता है और पुरुष के बिना स्त्री का जीवन भी अपूर्ण है। ऐसी अन्योन्याश्रित जीवन सच्चाई को कविता बयान करती है। उपरोक्त तीनों कविताओं के केन्द्र में स्त्री के जीवन को, स्त्री की अस्मिता को एवं स्त्री के उद्धार की आवश्यकता को चित्रित किया है। पर कवयित्री ने कविताओं के अंत में सवालिया चिह्न व आश्चर्य चिह्न लगाया है। इससे पाठक के मन में बारंबार यही सवाल उठ जाता है कि उत्तराधुनिक समय में स्त्री कहाँ तक स्वतंत्र है और सुरक्षित है? अतः त्रेतायुग एवं द्वापर युग के उत्थान के बाद भी कलियुग में स्त्री की हालत सुरक्षित नहीं है। पुराण के

आद्य प्रारूपों के तहत कवयित्री ने समकालीन समाज की व्यवस्थाओं की ओर इशारा किया है। जब तक स्त्री के प्रति समाज का दृष्टिकोण नहीं बदलेगा तब तक स्त्री का सही उद्धार संभव नहीं होगा। 'अहल्या' को श्रीराम द्वारा अपना रूप एवं आकार प्राप्त हुआ था, वहीं उसकी अस्मिता थी। 'कुब्जा' को कृष्ण के द्वारा कुरुपता से सौंदर्य प्राप्त हुआ। वहीं उसकी अस्मिता बनी थी। 'सति' को पुरे भारतीय सांस्कृतिक परिवेश में प्रतिष्ठा मिली है। सति के मन की पवित्रता ही उसकी अस्मिता है। वर्तमान समय में स्त्री पर होनेवाले अत्याचारों के बावजूद भी स्त्री को अपनी अस्मिता को बरकरार रखने की लगातार कोशिश करनी ही चाहिए। अपने ऊपर मँडरानेवाले अस्मिता के संकटों से उबरने की ताकत को बनाए रखना हमारे समय की माँग भी है। कवयित्री इन तीनों आद्य प्रारूपों से स्त्री सशक्तीकरण की आवश्यकता को आवाज़ दे रही हैं।

संदर्भ

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प्रस्तुतकर्ता

डा. प्रिया

सह प्राध्यापक, हिन्दी विभाग

के.जी कॉलेज, केरल

Impact Factor – 6.625

ISSN – 2348-7143

INTERNATIONAL RESEARCH FELLOWS ASSOCIATION'S
RESEARCH JOURNEY

Multidisciplinary International E-Research Journal

Peer Reviewed & Indexed Journal

October-2019 Special Issue – 203

गांधी विचारधारा एवं ग्रामस्वराज्य संकल्पना

अतिथि संपादक :

डॉ. अजयकुमार मोहबंसी
प्राचार्य,

कला एवं वाणिज्य पदवी महाविद्यालय,
पेट्रोलपंप जवाहरनगर,
त. जि. भंडारा

विशेषांक संपादक

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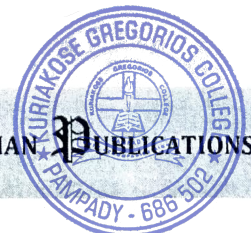


This Journal is indexed in :

- Scientific Journal Impact Factor (SJIF)
- Cosmoc Impact Factor (CIF)
- Global Impact Factor (GIF)
- International Impact Factor Services (IIFS)

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डॉ. प्रिया ए.

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गांधीजी एक व्यक्ति नहीं, एक विचारधारा का नाम है। उनका व्यक्तित्व बहुमुखी तथा बहुआयामी था। जीवन के सभी क्षेत्रों के बारे में गांधीजी ने विचार किया है। और अपनी एक विशिष्ट छाप प्रस्तुत की है। धर्म, राजनीति, समाज जैसे क्षेत्रों में अपना मौलिक योगदान दिया है। वे सत्य, अहिंसा आदि सनातन मूल्यों के पक्षपाती थे। उनकी सरलता की पराकाष्ठा का व्यक्तित्व एवं जीवन वर्तमान के सामाजिक, राजनीतिक एवं अंतर्राष्ट्रीय परिप्रेक्ष्य में भी बहुत ही प्रासंगिक है। इसलिए गांधीजी के बारे में उनके देहांत के 71 वर्ष के बाद भी चर्चाएँ हो रही हैं।

हमारे देश के सामाजिक परिवर्तन एवं राष्ट्रनिर्माण में गांधीजी का महत्वपूर्ण योगदान है। गांधीजी के सिद्धांत लोकतान्त्रिक एवं सत्य की कसौटी पर कसे-खरे सिद्धांत हैं। उनकी आस्थाएँ अडिग हैं। उन्होंने स्वराज को सब से बड़ा आत्मानुशासन, सत्याग्रह को सब से बड़ा अस्त्र एवं शिक्षा को सब से बड़ी नैतिकता माना है। गांधीजी युवाओं को सामाजिक परिवर्तन का सब से बड़ा औजार मानते थे। वे हमेशा चाहते थे कि सामाजिक परिवर्तनों, सामाजिक कुरीतियों, सती प्रथा, बाल विवाह, अस्पृश्यता, जाति व्यवस्था के उन्मूलन के विरुद्ध युवा लोग आवाज उठाएँ। उनका मानना था कि शोषणमुक्त स्वावलम्बी एवं परस्पर पोषक समाज के निर्माण में युवाओं की अहम् भूमिका होनी चाहिए।

गांधीजी का सामाजिक दर्शन :-

गांधीजी के दर्शन के केन्द्र में सारी सृष्टि का विकास और मानव का इतिहास ही था। जीवन, मानव, समाज और जगत का नैतिक भाष्य इसमें समाहित था। इसी दृष्टिकोण से अहिंसा का प्रादुर्भाव हुआ। वे मानते हैं कि जगत में जो कुछ अनैतिक है, वह सब हिंसा के अंतर्गत आता है। स्वार्थ, दम्भ, लोलुपता, अहंकार, भोग की प्रवृत्ति ये सब उन्हें पशुभाव ही लगते थे। क्योंकि ये पशुता, अमानवता और अनैतिकता ही मनुष्य को अनैतिकता की ओर ले जाती है। उन्होंने समाज को वीरता, दृढता, संकल्प और धैर्य को आधार बनाकर जीने का पाठ सिखाया।

गांधीजी की चिंतनधारा से असहयोग और सत्याग्रह का जन्म हुआ। यही उनकी हिंसक क्रांति, रक्तहीन विप्लव और हिंसाहीन युद्ध का मूर्त रूप है। उनकी दृष्टि में अहिंसा अमोघ शक्ति है, जिसका पराभव कभी हो नहीं सकता। अहिंसा नैतिकता पर आश्रित है, अतः सत्य है और सत्य की सदा विजय होती है। इस प्रकार संसार के सामने अहिंसा के रूप में उन्होंने उज्वल, महान और नैतिक पथ निर्मित किया। इससे मनुष्य समाज और जगत को गतिशील होने की प्रेरणा मिलती है। अहिंसक पथ को प्रदर्शित करके वे कल्पना करते हैं कि मनुष्य का जीवन, समाज और सम्पूर्ण जगत की व्यवस्था की रचना इस पथ के द्वारा संपन्न हो सकता है।

गांधीजी में भगवान राम की मर्यादा, श्रीकृष्ण की अनासक्ति, बुद्ध की करुणा, ईसा का प्रेम एक साथ ही समाविष्ट दिखाई देते हैं। उनके इन मौनिक विचारों ने मानव समाज के विकास के इतिहास में एक अत्यंत उज्वल और पवित्र अध्याय की रचना की है। ऊँचे श्रेष्ठ आदर्शों पर धर्म और नैतिकता पर, प्राणिमात्र के कल्याण की भावना पर जीवनोंत्सर्ग करनेवाले महापुरुषों की समस्त



पंजीयन संख्या / RNI/TELHIN/2016/70799

ISSN 2456-9445

खंड-3, अंक-1, पौष-फाल्गुन 2075 / जनवरी-मार्च, 2019

समन्वय दक्षिण



समन्वय दक्षिण

दक्षिण भारत की साहित्य एवं संस्कृति केंद्रित पत्रिका

खंड-3 अंक-1

पौष-फाल्गुन 2075/जनवरी-मार्च, 2019

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हैदराबाद केंद्र

(मानव संसाधन विकास मंत्रालय, भारत सरकार)



मलयालम यात्रा साहित्य के सर्वश्रेष्ठ मार्गशिला : एस.के.पोट्टेकाट्ट

डॉ. प्रिया ए.

यात्रा वृत्तांत गद्य साहित्य की एक विधा है। जब सौंदर्यबोध की दृष्टि से उल्लास भावना से प्रेरित होकर यात्रा करता है, और उसकी मुक्त भाव से अभिव्यक्ति करता है उसे यात्रा साहित्य या यात्रा वृत्तांत कहते हैं। मलयालम साहित्य में अपने वृत्तांतों के द्वारा पाठकों के मन पर गहरा अमिट प्रभाव डालनेवाले लेखक हैं एस.के.पोट्टेकाट्ट (1913-1982)। अपनी नौकरी त्याग कर 1945 से उन्होंने अपनी यात्रा का शुभारंभ किया था। एक रोमांटिक कवि की मानसिकता लेकर उन्होंने दुनिया के विभिन्न राज्यों की यात्रा की थी। वहाँ के सभी लोगों के प्रति उनके मन में प्रेम की भावना थी। उतना ही नहीं हर एक राज्य की प्रकृति एवं सौंदर्यबोध की भावना उनके सभी यात्रा वृत्तांतों में झलक रही है। जितनी रोचकता से हम उनके उपन्यास एवं कहानी का अध्ययन करते हैं, उसी प्रकार यात्रा साहित्य का अध्ययन भी कर सकते हैं। पोट्टेकाट्ट के यात्रा वृत्तांतों ने ही मलयालम के यात्रा साहित्य को संपन्न किया। उनके प्रसिद्ध यात्रा साहित्य हैं- 'काप्पिरिकलुड़े नाट्टिल' (1951), 'इन्डोनेशियन डयरी भाग-1, भाग-2' (1954, 58), 'नैल डयरी' (1954), 'इन्नत्ते यूरोप' (आज का यूरोप) (1955), 'पातिरा सूर्यन्ते नाट्टिल' (1956), 'सोवियट डयरी' (1957), 'बालिद्वीप' (1958), 'बोहीम्यन चित्र' (1960), 'हिमालय साम्राज्य में' (1967), 'नेप्पाल यात्रा' (1970), 'लंदन नोटबुक' (1970), 'कयूरो कत्तुकल' (1974) आदि। ये सभी रचनाएँ 1950 से 1975 तक के समय में प्रकाशित हुई थीं।

काप्पिरिकलुड़े नाट्टिल (आफ्रिका की जनजातियों के देश में) नामक यात्रावृत्तांत 1949 में आफ्रिका यात्रा के दौरान लिखा गया है। इसमें आफ्रिका की यात्रा में हुए अनुभवों एवं दृश्यों को स्थान दिया गया है। उस समय पूर्वी आफ्रिका के सभी राज्यों में अंग्रेजों का शिकार होना पड़ा था। पूर्वी आफ्रिका की भारतीयों के बारे में, उनके प्रति होनेवाले अन्यायों के बारे में भी उन्होंने इस रचना में चर्चा की है।

मुंबई से समुंद्र के मार्ग से दस दिनों की यात्रा के बाद वे आफ्रिका के पूर्वी दिशा में स्थित 'मोम्बासा' बंदरगाह पहुँच गए। वहाँ उन्होंने एक बड़े नीग्रो की प्रतिमा देखी। वह प्रतिमा देखकर उनको लगा कि आफ्रिका के सभी जनजातियों के प्रतिनिधित्व इसके द्वारा हो रहा है। आफ्रिका की जनजातियों को ही नीग्रो कहा जाता है। नीग्रो जनजाति का इतिहास संबंधी जानकारी भी इसमें दी गयी है। इन जनजातियों को मनुष्य एवं प्रकृति के द्वारा कई प्रकार के दुरनुभवों का शिकार होना पड़ा था। आफ्रिका में नीग्रो के प्रति अंग्रेज वर्ग गुलाम जैसा व्यवहार करते थे। अगर उन्हें किसी घर, बाग या कारखाने में नौकरी के लिए रखा जाता है तो मजदूरी के साथ 'पोषा', (खाद्य पदार्थ या उसके लिए पैसे) भी देना पड़ता था। अपने जन्मस्थान में उनके लिए कोई अधिकार नहीं होता। अपने देश में रहने के लिए उसे



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MAH/MUL/03051/2012
ISSN-2319 9318

Peer Reviewed International Refereed Research Journal

V I D Y A W A R T A®

Special Issue, October 2019

स्वामी रामानंद तीर्थ मराठवाडा विश्वविद्यालय, नांदेड
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MAH/MUL/ 03051/2012

ISSN :2319 9318



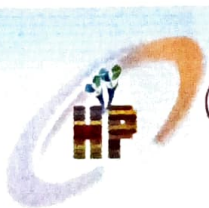
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बहिर्जी स्मारक महाविद्यालय
बसमतनगर, जि.हिंगोली
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समकालीन हिंदी साहित्य में स्त्री चेतना

संपादक
डॉ.सुभाष क्षीरसागर
डॉ.रेविता कावले
डॉ.शेख रजिया शहेनाज



Reg.No.U74120 MH2013 PTC 251205
Harshwardhan Publication Pvt.Ltd.

At.Post.Limbaganesh,Tq.Dist.Beed
Pin-431126 (Maharashtra) Cell:07588057695,09850203295
harshwardhanpubli@gmail.com, vidyawarta@gmail.com

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सुशीला टाकभोरे के नाटक में दलित जीवन की कारुणिक दास्तान

डॉ. प्रिया ए.

असिस्टेंट प्रोफेसर, हिन्दी विभाग, के.जी. कॉलेज
पम्पाडी, कोट्टयम, केरल

सुशीला टाकभोरे समकालीन हिन्दी साहित्य की महत्वपूर्ण लेखिका हैं; जिन्होंने अनेक कविताएँ, कहानियाँ, आत्मकथा एवं अन्य साहित्यिक रचनाओं के माध्यम से हिन्दी साहित्य को संपन्न किया। 'नंगा सत्य' सुशीला टाकभोरे द्वारा लिखा गया इक्कीसवीं सदी का उल्लेखनीय नाटक है। इस नाटक के माध्यम से भारतीय समाज व्यवस्था में परिवर्तन एवं दलित साहित्य की वैचारिकी की आवश्यकता को आम आदमी तक पहुँचाने का प्रयास किया है। इस दलित नाटक का आधार सवर्ण-पूँजीवादी व्यवस्था के विरुद्ध विद्रोह और नकार है। नाटक की शुरुआत से अंत तक दलित जीवन संघर्ष का स्वर गूँज उठता है। यह जीवन संघर्ष का स्वर ही प्रतिरोध है, जो निहत्थे का हथियार है। वर्तमान समय के मानवीय विरोधी पक्ष से समाज को, मानवता को बचाने के लिए साहित्य में प्रतिरोधी संस्कृति की जरूरत है।

'नंगा सत्य' नाटक तीन अंकों में विभक्त है। करीब बीस चरित्र प्रस्तुत नाटक में अपनी भूमिकाओं को निभाते हैं। प्रस्तुत नाटक की कथावस्तु के माध्यम से सत्तावर्ग के दमन एवं शोषण के खिलाफ दलित वर्ग की आवाज बुलंद होती है। सामाजिक, धार्मिक, आर्थिक, शैक्षिक, राजनीतिक एवं सांस्कृतिक शोषण के विरुद्ध दलित जीवन संघर्ष का स्वर गूँज उठता है। सुशीला टाकभोरे ने सामाजिक जीवन व्यवस्था में दलितों पर होनेवाले शोषण के विविध आयामों को इस नाटक में दर्शाया गया है।

सामाजिक व्यवस्था के अंतर्गत छुआछूत के नाम पर दलितों पर होने वाला अन्याय का चित्रण प्रस्तुत नाटक का पात्र कृपाशंकर; जो दलित वर्ग का है, उसके द्वारा यों किया है - "हमारा रामू काका बता रहा था, मास्टर जी ने उनके लड़के को कक्षा में बहुत पीटा है। मास्टर कहता है - "भंगी को स्कूल में पढ़ने नहीं दूंगा। सबको छूकर छूत करता है...."

गया है इस तथ्य की ओर नाटक के दृश्य इशारा करते हैं।

नाटक का एक दूसरा दलित पात्र जिसका नाम कमल है; वह अपने साथी मुखराम से सामंतवादी व्यवस्था के विरुद्ध यों कहता है - "मैं और कृपाशंकर शहर जाकर पढ़-लिखकर आये हैं। शहर में रहकर, हमने गाँव के अपने लोगों की दुर्दशा को समझा है। अब हम अपने जाति-समुदाय की स्थिति को बदलने के लिए कार्य कर रहे हैं...."

समाज व्यवस्था में दलितों पर 'बेगारी' जैसी कुप्रथा लगाई जा रही थी। इसमें दिन-रात दलितों को सत्तावर्ग की बेगारी करना पड़ती थी। ऐसी व्यवस्था के विरुद्ध व्यंग्य भाव से इस नाटक का पात्र सुनीत जो शिक्षित दलित अधिकारी है इस प्रकार कहता है - "रात-दिन अपनी सेवा करवाते रहना ही उनके सेवा कार्य हैं। खेतों में, कारखानों में, घर में, गाँव में - हर जगह, काम करने वाले हमारे लोगों से, कसकर सेवा लेते हैं।"³

सुशीला टाकभोरे ने नाटक के पूर्वभाग में सवर्णों को शोषणयुक्त मानसिकता को व्यक्त किया है। सवर्णों के प्रतिनिधि हैं - रामपुर गाँव के शान-शोकत वाले संपन्न जमीन्दार ठाकुर धर्नासिंह; जो खुद को नेक महानेता मानता है और ठाकुर धर्नासिंह का बेटा सत्यजीत सिंह; जिसे लेखिका ने 'बिगड़ा रईसजादा' और रंगीला नवयुवक संज्ञा से अभिहित किया है। इस बाप-बेटे के अत्याचारों के विरुद्ध नाटक का अवर्ण पात्र कृपाशंकर अपनी मानसिक पीड़ा द्वारा दलित समाज का जीवन यथार्थ यों व्यक्त करता है - "हमारी समाज-व्यवस्था का नंगा सत्य यही है। हम शोषित, पीड़ित-दलित कबसे परिवर्तन की राह देख रहे हैं, मगर आज भी हमारी वही दुर्गति है।"⁴

पूँजीपति वर्ग द्वारा स्त्रियों पर होनेवाले अत्याचार एवं शोषण भी एक सामाजिक सच्चाई है। स्त्री होने के कारण, दलित वर्ग की स्त्री होने के कारण उसे दोहरे शोषण का शिकार बनना पड़ता है। ऐसी विद्रुपात्मक हालत को प्रस्तुत नाटक की स्त्री पात्र नीलिमा जो दलित युवती एवं सामाजिक कार्यकर्ता है; अपने प्रतिरोध के जरिए यों स्पष्ट करती है - "कितनी महिलाएँ शोषित पीड़ित हैं, लेकिन वे सामने आने के लिए तैयार नहीं होतीं। क्यों? इसका कारण है - उन पर अधिक जुल्म किये जाते हैं। उन्हें बेइज्जत किया जाता है। उन्हें झूठा बदनाम किया जाता है.... उन्हें जान से खत्म कर दिया जाता है। साथियों, हम स्त्रियाँ न फूल हैं, न चिनगारी हैं। अब हमें बनना है मशाल... क्रांति की मशाल।"⁵

ठाकुर के बेटे सत्यजीत सिंह द्वारा उस पर बलात्कार भी होता है। इन घटनाओं के कारण उसके मन में सवर्ण-पूँजीवादी व्यवस्था के प्रति क्रांति की ज्वाला भड़क उठती है।



Peer Reviewed

ISSN 2394 - 6482
Volume - IV
June - 2018

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A Multidisciplinary
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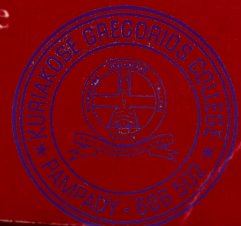
*Modern Perspectives and Innovative Practices
in Children's Literature*

हिन्दी साहित्य में प्रतिरोध की संस्कृति

മാതൃഭാഷയുടെ രാഷ്ട്രീയം



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4

‘नंगा सत्य’ में चित्रित दलित जीवन संघर्ष का स्वर

The struggles of Dalit life depicted on ‘Nanga Satya’

Dr. Priya A.

casteism that harms our social fabric is a potent force even today, and forms the focal point of this study. The resistance put up by the marginalized against the exploitative oppression of the upper classes holds a ray of hope for the downtrodden.

डॉ. सुशीला टाकभौरे समकालीन हिन्दी साहित्य की महत्वपूर्ण लेखिका हैं, जिन्होंने अनेक कविताएँ, कहानियाँ, आत्मकथा एवं अन्य साहित्यिक रचनाओं के माध्यम से हिन्दी साहित्य को संपन्न किया। ‘नंगा सत्य’ सुशीला टाकभौरे द्वारा लिखा गया इक्कीसवीं सदी का उल्लेखनीय नाटक है। इस नाटक के माध्यम से भारतीय समाज व्यवस्था में परिवर्तन एवं दलित साहित्य की वैचारिकी की आवश्यकता को आम आदमी तक पहुँचाने का प्रयास किया है। इस दलित नाटक का आधार सवर्ण-पूँजीवादी व्यवस्था के विरुद्ध विद्रोह और नकार है। नाटक की शुरुआत



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दर्जस्ट प्रोफेसर
खेयों विभाग, के.जी. कॉलेज
डी, कोट्टयम- 686502
9447294227

ournal

ISSN 2249-8486

पंजीकरण संख्या

UPHIN 41 252/24/1/2010-TC

ICRJIFR Impact Factor 3.7921



अनुसंधान विमर्श

समकक्ष विशेषज्ञ विद्वत् समिति द्वारा समीक्षित एवं मूल्यांकित
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Peer Committee Reviewed and Referred International
Multi Disciplinary Half Yearly Research Journal

वर्ष-9 अंक-16

जनवरी-जून 2019



ISSN 2249-8486

पंजीकरण संख्या

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संरक्षक

प्रो. प्रदीप श्रीधर

निदेशक

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सम्पादक

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आगरा-282004 (उ.प्र.)

सहायक संपादक

तनुजा पदारथ

व्याख्याता, महात्मा गाँधी संस्थान

मोका (मॉरीशस)

वर्ष-9, अंक-16

जनवरी-जून, 2019



ज्योति चावला के काव्य संग्रह 'माँ का जवान चेहरा' में अभिव्यक्त समकालीन समस्याएं एवं मानवीय सरोकार

-डॉ. प्रिया ए.

हिन्दी युवा लेखन के क्षेत्र में ज्योति चावला का नाम महत्वपूर्ण है। ज्योति चावला का काव्य संग्रह 'माँ का जवान चेहरा' वर्ष 2013 में प्रकाशित हुआ। इस संकलन की कविताओं में हमारे समाज के हाशिए कृत जनता का जीवन अपने हक की लड़ाई करने वाले लोगों के जीवन संघर्ष का आकलन प्रस्तुत है। यहाँ हाशिया एक सीमित तत्व नहीं है, बल्कि एक विस्तृत दायरा है। इसमें जो चिन्तन, किसान एवं विकास की आड़ में लगातार विस्थापन के शिकार होने वाले आमजन का कटु जीवन यथार्थ चित्रित किया है। इस प्रकार ज्योति चावला की कविता में मानवीय सरोकार की भावना दृष्टिगत होती है।

वर्तमान समय के नगरीकरण की एक सामाजिक सच्चाई को 'दयाराम' नामक कविता द्वारा शब्दबद्ध किया है। आजकल हमने महानगरों में मेट्रो के काम चल रहे हैं। कई मजदूर वहाँ आमदनी के लिए कड़ी मेहनत करते हैं। 'दयाराम' मात्र एक व्यक्ति ही नहीं, वह पूरे मेहनतकश वर्ग का प्रतिनिधि बनकर हमारे सामने उपस्थित होता है। 12 जुलाई, 2009 को दिल्ली में हुई मेट्रो दुर्घटना में मारे गए मजदूरों में 'दयाराम' भी एक है। इसी दुर्घटना को इस कविता की पंक्तियाँ चित्रित करती हैं-

"वह जो मारा गया कल सुबह तड़के पाँच बजे
उसका नाम दयाराम वल्द मायाराम था
गाँव नौतनवा जिला गोरखपुर, उत्तर प्रदेश का रहने वाला दयाराम
आया था शहर साढ़े चार महीने पहले
गाँव से शहर आए दयाराम के पास केवल सत्तर रुपए
गाँव से शहर की दूरी पाटने के लिए
गाँव से शहर आया दयाराम
लाया था ढेर सारी उम्मीदें कि
शहर पहुँचेगा तो कमाएगा खूब पैसा और
दूर हो जायेंगे सारे कष्ट उसके परिवार के
मारा गया गाँव से शहर आया दयाराम
और शहर के मल्बे में दफन है उसका लाश।"¹

बुनियादी ज़रूरतों की पूर्ति के लिए वह अपने गाँव से शहर आया था। नगरीकरण के माहौल में वह सदा जूझता रहता है। अंत में दुर्घटना के कारण उसकी मृत्यु होती है और उसकी लाश शहर के किसी अन्जान मलबे में दफनायी जाती है।

भूमण्डलीकरण की उपज नई अर्थ व्यवस्था के तले दबने वाले आम मनुष्य की तनावग्रस्त जिन्दगी का दस्तावेज सच नामक कविता प्रस्तुत करती है—

"एक मामूली सी दुकान पर
सत्ताइस सौ रुपए महीने की नौकरी करने वाला
वह मामूली सा आदमी
पिछले कुछ दिनों से बीमार है



हिन्दी-अनुशीलन

(पीयर रिव्यूड व यूजीसी केयर से अनुमोदित जर्नल)

वर्ष 61 सितम्बर-दिसम्बर 2019 अंक 3-4 ISSN : 2249-930X

कालजयी विशेषांक-II

परामर्शदाता

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प्रो. सुरेन्द्र दुबे
प्रो. सूर्यप्रसाद दीक्षित

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प्रो० मीरा दीक्षित

भारतीय हिन्दी परिषद् प्रयाग

पीयर रिव्यूड रिसर्च जर्नल
(यूजीसी केयर लिस्ट में शामिल)

हिन्दी अनुशीलन / 1

ISSN : 2249-930X



केदारनाथ सिंह की कविता में सामाजिक पक्षधरता

डॉ० प्रिया ए.

केदारनाथ सिंह समकालीन हिन्दी कविता के प्रमुख हस्ताक्षर के रूप में विख्यात हैं। 'तीसरे सप्तक' से शुरु होकर 'सृष्टि पर पहरा' तक व्याप्त उनकी काव्य-यात्रा जनपदीय चेतना से संपृक्त है। अपने पहले काव्य संकलन 'अभी विल्कुल अभी' से लेकर केदारनाथ सिंह संवेदनशील, काव्य के रसिक जन तक कविता के सहज संप्रेषण के लिए एक सही उपादान की तलाश करते हैं। कविता में विंव विधान को विकल्प के रूप में उन्होंने प्रस्तुत किया। लगभग बीस साल के बाद दूसरा संकलन 'जमीन पक रही है' में अपने आसपास के जगत को प्रश्नांकित दृष्टि से वे परखते हैं। पूरे परिवेश के बारे में आत्मालोचन करते हुए लंबे आत्मधैर्य के साथ वे लिखते हैं। अपनी आत्माभिव्यक्ति की इस प्रक्रिया में केदारनाथ सिंह ने अपने समय और परिवेश की बेहतर समझ के लिए अच्छी कोशिश जारी रखी। अपने तीसरे काव्य संग्रह 'यहाँ से देखो' में उनका काव्य-संसार आज के भारतीय समाज के प्रति गहरी संवेदनात्मक उन्मुखता या लगाव को प्रमाणित करने वाला जगत है।

समूचे वातावरण में व्याप्त मानव-विरोधी मुहिम में मानव जीवन लुप्त हो जाने के खतरे के प्रति कवि आगाह करते रहते हैं। ढलती हुई बीसवीं सदी के अन्धे मोड़ पर 'बाघ' दर असल समय के विध्वंसों के खिलाफ मनुष्य के संघर्ष की लोकगाथा है। वस्तुतः हमारे चारों ओर के मायावी समय को ही 'बाघ' नामक संकलन में प्रस्तुत किया है। बाद में प्रकाशित 'अकाल और सारस' और 'उत्तर कबीर और अन्य कविताएँ' नामक संकलनों में नई सदी जो परिवर्तन का दौर रही है, तदनुरूप होने वाले सामाजिक परिवर्तन एवं मानव जीवन विसंगतियों की अनुगूँज सुनाई देती हैं। उनका अगला काव्य संकलन 'तालसताय और साइकिल' देशज-नागर-वैश्विक इतिहास और भूगोल-विमर्श के बीच एक पुल बनाता है। इस संकलन की हर कविता एक नया प्रस्थान है जो सहज एवं जटिल जीवन को एक साथ साधने की विलक्षण कला का साक्ष्य बनती है। प्रस्तुत काव्य संकलन उनकी एक लंबी काव्य-यात्रा का एक ऐसा पड़ाव है, जहाँ समकालीन अनुभव के कई नए अनुषंगों को खोलते हैं।

उनका अंतिम काव्य संकलन 'सृष्टि पर पहरा' तक आते-आते कविता और मनुष्य को बचाने की उनकी लगातार कोशिश से हम अवगत हो जाते हैं। केदारनाथ सिंह का यह नया संग्रह कवि के इस विश्वास का ताजा साक्ष्य है कि अपने समय में प्रवेश करने का रास्ता अपने स्थान से होकर जाता है। यहां स्थान का सबसे विश्वसनीय भूगोल थोड़ा और विस्तृत हुआ है, जो अनुभव के कई सीमान्तों को छूता है। अपने चारों ओर के जीवन की स्वीकृति एवं अभिव्यक्ति उनकी कविता की



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असिस्टेंट प्रोफेसर हिन्दी विभाग,
के.जी. कालेज, पाम्पाडी,
कोट्टयम-686502 केरल
मो0-9447294227

150 / हिन्दी अनुशीलन पीयर रिव्यूड रिसर्च जर्नल
(यू0जी0सी0 केयर लिस्ट में शामिल) ISSN : 2249-930X



ISSN - 2348-7143

INTERNATIONAL RESEARCH FELLOWS ASSOCIATION'S

RESEARCH JOURNEY

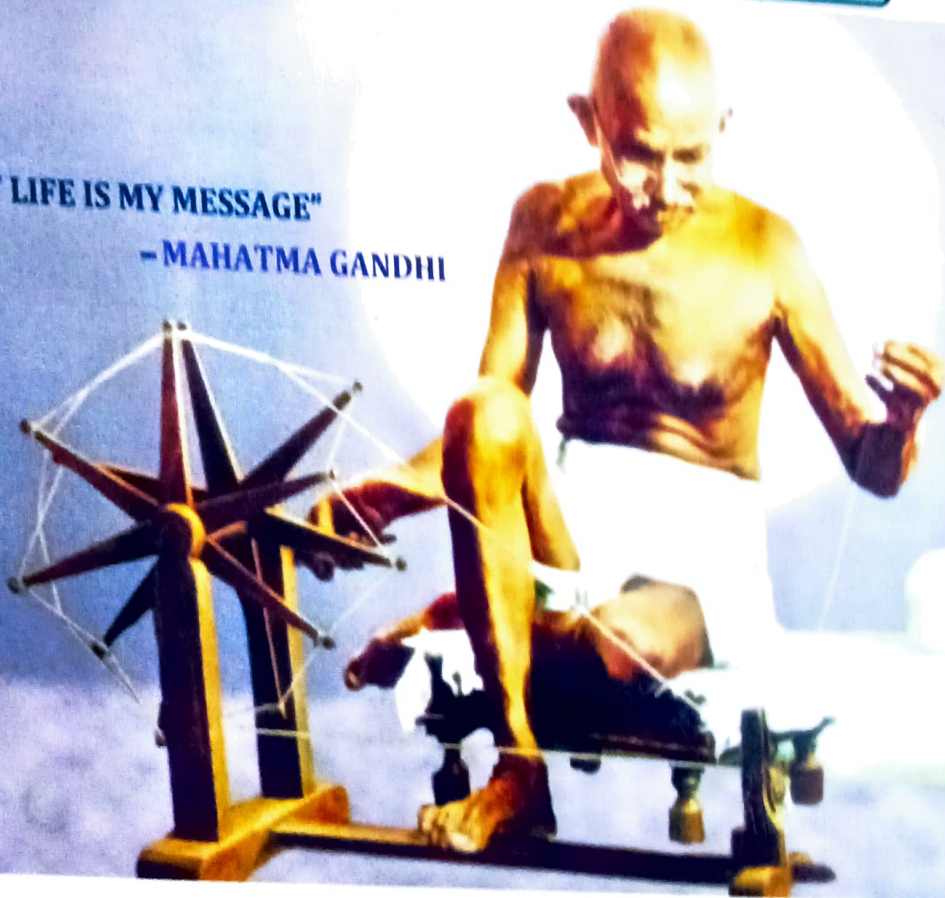
International Multidisciplinary E-Research Journal

PEER REFREED & INDEXED JOURNAL

February - 2020 Special Issue - 224 (C)

RELEVANCE OF GANDHIAN THOUGHTS

"MY LIFE IS MY MESSAGE"
- MAHATMA GANDHI



Guest Editor :

Dr. Mrs. M. V. Waykole
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This journal is indexed in :

- Scientific Journal Impact Factor (SJIF)
- Cosmos Impact Factor (CIF)
- Global Impact Factor (GIF)
- International Impact Factor Services (IIFS)



INTERNATIONAL RESEARCH FELLOWS ASSOCIATION



Impact Factor – 6.625

ISSN – 2348-7143

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SWATIDHAN INTERNATIONAL PUBLICATIONS

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गाँधीजी एवं उनके बहुआयामी चिंतन

डॉ. प्रिया ए.

असिस्टेंट प्रोफेसर

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गाँधीजी का व्यक्तित्व एक बहुआयामी व्यक्तित्व था। जीवन के सभी क्षेत्रों के बारे में गाँधीजी ने विचार किया है और अपनी एक विशिष्ट छाप प्रस्तुत की है। धर्म, राजनीति, समाज जैसे क्षेत्रों में अपना मौलिक योगदान दिया है। वे सत्य, अहिंसा आदि सनातन मूल्यों के पक्षपाती थे। सरलता की पराकाष्ठा का व्यक्तित्व एवं जीवन वर्तमान के सामाजिक, राजनीतिक एवं अंतर्राष्ट्रीय परिप्रेक्ष्य में भी बहुत ही प्रासंगिक है। इसलिए गाँधीजी के बारे में उनके देहान्त के 71 वर्ष के बाद भी चर्चाएँ हो रही हैं।

हमारे देश के सामाजिक परिवर्तन एवं राष्ट्रनिर्माण में गाँधीजी का महत्वपूर्ण योगदान है। गाँधीजी के सिद्धांत लोकतांत्रिक एवं सत्य की कसौटी पर कसे-खरे सिद्धांत हैं। उनकी आस्थाएँ अड़िग हैं। उन्होंने स्वराज को सब से बड़ा आत्मानुशासन, सत्याग्रह को सब से बड़ा अस्त्र एवं शिक्षा को सब से बड़ी नैतिकता माना है। गाँधीजी युवाओं को सामाजिक परिवर्तन का सब से बड़ा औज़ार मानते थे। वे हमेशा चाहते थे कि सामाजिक परिवर्तनों, सामाजिक कुरीतियों, सती प्रथा, बाल विवाह, अस्पृश्यता, जाती व्यवस्था के उन्मूलन के विरुद्ध युवा लोग आवाज़ उठाएँ। उनका मानना था कि शोषणमुक्त स्वावलंबी एवं परस्पर पोषक समाज के निर्माण में युवाओं की अहम् भूमिका होनी चाहिए।

वे हमेशा देश की आर्थिक मज़बूती के पक्षधर रहे हैं, गाँधीजी ने हमेशा पूँजीवादी व समाजवादी विचारधारा का विरोध किया है। उनकी अर्थ व्यवस्था के केंद्रबिंदु गाँव थे। उनकी धारणा यह रही थी कि ग्रामीण बेरोज़गारों का शहर की ओर पलायन भारत की ज्वलंत समस्या बन सकती है। गाँवों में ही, युवाओं को रोज़गार उपलब्ध कराने का मार्ग सिर्फ कुटीर उद्योग ही हो सकते हैं। अतः भारतीय युवा हमेशा से गाँधीजी के चिंतन के केंद्रबिंदु रहे हैं। महात्मा गाँधी गाँवों को राष्ट्र के उत्पादन की सबसे छोटी इकाई के रूप में देखते थे। वे जिस भारत की कल्पना करते थे, उस भारत में पंचायतों को स्वावलंबी बनाने पर जोर दिया था। वे अर्थ पक्ष एवं नैतिक पक्ष को एक दूसरे के पूरक मानते थे। अर्थात् आर्थिक प्रतिस्पर्धा में हमें अपनी नैतिकता को छोड़ना या भूलना नहीं चाहिए। क्योंकि नैतिकता हमारे देश की प्रकृति के नियमपूर्ण सत्य है। उन्होंने भारत की बेरोज़गारी को बढ़ते देखकर खादी ग्राम उद्योग को बढ़ावा दिया था। वे खादी को एक वस्त्र नहीं एक विचार के रूप में मानते थे। अतः खादी को भारत की आर्थिक स्वतंत्रता तथा एकता का प्रतीक मानते थे। इसी उद्योग के लिए उन्होंने चर्खे को उपकरण के रूप में चुना; जो सस्ता एवं कम पूँजी पर सभी घरों में आसानी से इस्तेमाल हो सकता था। उन्होंने चर्खे के ज़रिए हर तरह के विभेद को ख़तम करने की कोशिश की।

भारतीय लोक जीवन में गाँधी का आगमन उस समय हुआ था, जिस समय समाज दिशाहीन एवं निर्जीव था। ऐसे समय में गाँधी समाज के लिए एक ज्योति धारा बनकर आए और समाज को अपनी विलक्षण प्रतिभा अनुभव तथा गूढ़ चिंतन से सही दिशा देने में सक्षम सिद्ध हुए। इस दिशा में उनका सबसे अधिक योगदान स्त्री जीवन के क्षेत्र में रहा था। उनके युग को स्त्री जागरण का 'स्वर्ण-युग' भी कहा जा सकता है। उनका मानना था कि स्त्रियों की सामाजिक स्थितियों के सुधार के बिना देश का विकास नहीं हो सकता। इसलिए उन्होंने सर्वप्रथम समाज के समस्त स्त्रियों की दुर्दशा के जीवंत स्वरूप को उपस्थित किया और उसके सुधार पर विशेष बल दिया था। अपने समसामयिक



Impact Factor – 6.625 | Special Issue – 232 | February 2020 | ISSN – 2348-7143

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Impact Factor – 6.625 ▪ Special Issue - 232 ▪ February 2020 ▪ ISSN – 2348-7143

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Printed by : PRASHANT PUBLICATIONS, JALGAON



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डॉ. प्रिया ए.

असिस्टेंट प्रोफेसर

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समकालीन जीवन एवं परिवेश मशीनीयुग से घिरा हुआ है। ऐसी त्रासद हालत में मनुष्य एवं मनुष्यत्व का प्रतिस्थापन होता है। जटिल परिवेश के तहत पूरा माहौल जकड़ा जाता है। इस विद्रूपता ने भारतीय संस्कृति को शहरीय संस्कृति में तब्दील किया है। शहरीय संस्कृति के शिकंजे में पड़कर मानव संवेदनहीन बनते हैं। क्योंकि मशीनों का आविष्कार बुद्धि से होता है। संवेदनात्मक पक्षों से इसका कोई सरोकार नहीं होता। इस बुद्धि के द्वारा दुनिया में विज्ञान एवं प्रौद्योगिकी के क्षेत्र ने बड़ी रफ्तार से प्रगति पायी है। इसी रफ्तार ने आजकल के मानवजीवन को खौफनाक हालत में लाकर खड़ा किया है।

बीसवीं शताब्दी से ‘भूमंडलीकरण’ एक प्रमुख घटना बनी हुई है। जीवन के सभी स्तरों पर इस तथ्य के निशान भिन्न-भिन्न आकार में नज़र आते हैं। भूमंडलीकरण का मुखौटा पहनते हुए बाज़ारवादी संस्कृति आज पनपती नज़र आती है। इस बाज़ारवाद के कारण गाँव का रूप बदल गया है। बाज़ार की होड़ ने गाँव का कलेवर बदलकर उसे महानगर का रूप प्रदान किया है। पैसा कमाने की इच्छा से लोग गाँव से नगर में आये। औद्योगिक विकास ने नगरों को महानगरों का परिवेश दिया। यहीं से यांत्रिकी की खौफनाक संभावनाएँ ठोस रूप से उभरती आती हैं।

महानगर की यांत्रिकता भरी जिन्दगी ने महानगरीय संस्कृति को जन्म दिया। इस संस्कृति में घुट-घुटकर जीनेवाली जनता को निराशा, तनाव, अकेलेपन एवं परायेपन जैसे कटु अनुभवों से गुजरना पड़ता है। भविष्य सुरक्षित रखने के चक्कर में उन्हें अपना वर्तमान दाँव पर लगाना पड़ता है। ऐसे समय में उनका भविष्य धुँधला जाता है। आज के मानव-जीवन के हर क्षेत्र में एक प्रकार का बेडौलपन दीख पड़ता है। जनता को भीड़, शोर, यातायात, पर्यावरण प्रदूषण, रोज़गार की समस्या, पारिवारिक तथा सामाजिक विघटन, आवास की समस्या, राजनैतिक समस्याएँ एवं बाज़ारवाद जैसे जीवन विरोधी परिवेश का सामना करना पड़ता है।

महानगरों में घर सिर्फ एक ‘मकान’ होता है। व्यक्ति तो मात्र एक यंत्र बन गया है। उनके लिए जीने का मतलब है - सिर्फ अपने स्वार्थ-लाभ के लिए जीना। एक-दूसरे से कोई लगाव नहीं होता और न कोई रिश्ता। ऐसे वातावरण से पारिवारिक रिश्तों में दरारें पड़ जाती हैं। व्यक्ति का मन कुंठा, निराशा एवं ऊब से भर जाता है। इन समस्याओं से जूझते हुए व्यक्ति का वैचारिक पक्ष उजड़ने लगता है। उसके रंगीन सपने रंगहीन बन जाते हैं। उसकी जिन्दगी तबाही के सरहद पर आकर रुकेगी। श्रीलाल शुक्ल के उपन्यास ‘मकान’ में भी इसी समस्या को प्रस्तुत किया है।

‘मकान’ उपन्यास का नायक नारायण एक सितारवादक है। जीविका के लिए वह परिवार को दूसरी जगह छोड़कर शहर में आता है। शहर में रहने के लिए वह एक मकान की तलाश करता है। इस तलाश में वह चारों ओर भटकता है। वह एक कलाकार है। पर निर्भाग्यवश दुविधाओं के ग्रस्त होने से एक ओर उसका सितार से

साथ छूटने लगता है। इस सन्दर्भ में कलाकार का अस्तित्व डगमगाने लगता है। यहीं से उसके जीवन का बिखराव शुरू होता है। दूसरी ओर कर्मचारी यूनियन का नेता बारीन हालदार, पुरानी शिष्या श्यामा, वेश्या-पुत्री सिम्मी आदि से उसका रिश्ता जुड़ जाता है।

“सबेरे चार बजे मेरी नींद खुल गयी। चार बजे उठकर सितार का अभ्यास करने की मेरी आदत है और अपनी सभी आदतों में एक यही ऐसी है जिससे मुझे संकोच या असमंजस नहीं होता। इस होटल में मेरी इसी आदत की कब्र खोदी गयी है।” नारायण की मन की कसक यहाँ व्यक्त है। कलाकार को निरन्तर कला के अभ्यास की ज़रूरत है। मकान की तलाश में वह सदा भटकता रहा। पर उस मुंबई शहर में उसे रहने के लिए कोई मकान नहीं मिला। इसी कारण वह एक होटल में ठहरता है। पर वहाँ पर नारायण की दुर्गति हो रही थी। वह बीवी-बच्चों से दूर रहता है। महान सितारवादक नीलमणि बानर्जी का पुत्र होने पर भी वह एक श्रेष्ठ कलाकार न बन पाया। सितार कमरे के कोने में धूल और मकड़ियों के जाल में पड़ा हुआ था। अब उसके जीवन में दिगन्तहीन शून्यता छा गयी थी।

नारायण अपने चारों ओर व्यास अकेलेपन से मुक्त होना चाहता था। पर उसकी शून्यता को तोड़ने के लिए कुछ भी काफी न था - “न सारे दिन दफ्तर की निरर्थक आपाधापी, न शाम को अकेले सड़कों, पाकों, सिनेमाघरों की सैर, न किसी सस्ती बार में अपरिचितों के साथ शराबखोरी, न बारीन दा की यूनियन के पचड़े, न एक सफल सार्थक कलामय जीवन बिताने के संकल्प, न उस जीवन के लुभावने दिवास्वपन - कुछ भी काफी न था।” इस प्रकार महानगरीय संस्कृति ने उसे तहस-नहस कर डाला है। उसका जीवन एवं सपने सब कुछ इस यांत्रिकता के तले दब गये हैं। कलाकार एवं कला का अंत हुआ है। वह संकट के कगार पर खड़ा है।

महानगरों में कई प्रकार की समस्याएँ होती रहती हैं। सभी समस्याओं का समाधान आसानी से नहीं मिल पाता। उसके लिए जनता को जूझना पड़ता है। आम जनता के सामने महँगाई की समस्या एक चुनौती बनकर खड़ी होती है। आय से ज्यादा व्यय होता है। यह बेबसी महानगरीय जनता को भागीनी पड़ती है। जीवनयापन के लिए मानव गाँव छोड़कर महानगर में आ जाते हैं। ऐसी विसंगत हालत के खिलाफ उसे लड़ना पड़ता है। आमदनी को बढ़ाने के सिलसिले में

ISSN : 2394-563X

INDRAPASTHA *Review*

An International Refereed Biannual Research Journal
of Humanities and Multidisciplinary Studies



January - June 2019

Year - 6

Vol. : 6:1



ISSN : 2394-563X

INDRAPRASTHA *Review*

An International Refereed Bi-Annual Research Journal of
Humanities, Social Science and Multi-Disciplinary Studies

Editors :

Dr. N.C. Panda • Dr. Bishnu Charan Dash • Prof. K.N. Tiwari

Published By :

ABHISHEK PRAKASHAN

C-30, Second Floor, New Moti Nagar, New Delhi-15

(M) : 9811167357, 8368127189, 9911167357

E-mail : abhishekprakashan@gmail.com

January-June, 2019

Year : 6



Volume : 6:1

दलित समाज के स्त्री का जीवन यथार्थ (रजत रानी मीनू की कविताओं के संदर्भ में)

—डॉ. प्रिया ए.

रजत रानी मीनू समकालीन कविता के क्षेत्र की दलित कवयित्री के रूप में विख्यात है। उनकी सभी कविताएँ स्त्री-विर्मश के साथ-साथ मानवीय गरिमा और मनुष्य के निर्माण का संदेश देती हैं। 'पिता भी तो होते हैं' माँ उनका पहला औपचारिक काव्य संकलन है। इस संकलन की सभी कविताएँ एकान्त में दिया गया कवयित्री का निजी हलफनामा हैं। यह उनकी आँखों देखी सच्चाई का, जीवनानुभवों का काव्यमय प्रस्तुती है। 'कविता' क्या है? कविता किसे कहते हैं? इसकी परिभाषा देते हुए उन्होंने लिखा है—

“कविता एक उद्गार है/कविता एक समाज है
कविता मेरा देश है/कविता में भाव हों,
सार हीन नहीं/कविता सच में/एक लक्ष्य है।
कविता एक/सरल माध्यम है/दूसरों तक/पहुँचने का।
कविता एक संवेदना का सार है।/
कविता मनुष्यता से..../मनुष्यता का प्यार है।”¹¹

पुरुष समाज ने स्त्री को शोषिता बना दिया। इस शोषिता स्त्री के सम्मुख कई समस्याएं भी उपस्थित होती हैं। प्रस्तुत काव्य संकलन एक दलित-वंचित-प्रवंचित स्त्री के उत्थान-पतन, आरोह-अवरोह और स्वाभिमान का काव्यमय प्रस्तुतीकरण है। 'दलित कविता' नामक कविता के माध्यम से वे दलितों के जीवन के बारे में, दलितों के माँगों को दर्ज करती है—

“दलित कविता/दर्द है दर्द का
अहसास है/प्यार का समन्दर है
जीवन की सच्चाई है/समता की चाह है
स्वतन्त्रता का सन्देश है/मानव की गरिमा है
शिक्षा का मन्त्र है/जातियों का दंश है
समाज का तन्त्र है/दलित कविता
इंसान का/इंसान से
प्यार है, प्यार का/अहसास है”¹²

कसते थे व्यंग्य/तुम लग तो
वजीफे के लिए पढ़ते हो/सरकारी मेहमान हो तुम
मुझे याद है/दलित लड़कियों के लिए
नहीं गढ़े गये थे/ऐसे मुहावरे
जैसे गढ़े गये थे-
दलित लड़कों के लिए
हसरकार के दामाद हो'/तुम्हें पढ़ने की क्या ज़रूरत है?
वजीफा लो/ऐश करो।''¹⁰

इस कविता में पूरे दलित समाज की चर्चा की है। कवयित्री तो दलित वर्ग की प्रतिनिधी बनकर हमारे सामने उपस्थित होती है। स्वर्ण वर्ग द्वारा दलित वर्ग पर होने वाले अत्याचार के प्रति वे चिंतित है। मुख्यधारा वर्ग ने दलित वर्ग को हाशिएखत कर दिया था। शिक्षा के द्वारा ही दलित वर्ग के जीवन को मुक्ति का मार्ग प्राप्त होगा। यही कामना कवयित्री करती है।

रजत रानी मीनू की कविता में दलित स्त्री की दुस्थिती का यथार्थ अंकन हुआ है। शोषण से युक्त उत्पीड़न से नारी मुक्ति के लिए अपनी ओर से उन्होंने भरसक कोशिश की है। नारी समाज की समस्याओं को उजागर करके इस विडंबनात्मक हालत से उसे उबारने का आ]वान भी अपनी रचनाओं के माध्यम से उन्होंने किया है। इसी उम्मीद को मीनू जी ने हअच्छी लगती है लड़कियाँ' नामक कविता में संप्रेषित किया है-

“अच्छी लगती है/वे लड़कियाँ/जो हँसती हैं,
बतियाती हैं/पढ़ती हैं/बढ़ती हैं/अच्छी लगती हैं
वे लड़कियाँ, जो/अन्धविश्वासों के/खिलाफ लड़ती हैं।”¹¹

प्रस्तुत काव्य संकलन हपिता भी तो होते हैं माँ' स्त्री लेखन की धारा के प्रवाह को ज़रूर प्रबल करेगा। रजत रानी मीनू की रचनाएँ दलित समाज के स्त्री जीवन यथार्थ को उद्घाटित करने के साथ-साथ उनको नयी ऊर्जा देने में भी सक्षम सिद्ध होती हैं।

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केरल-686502
मो : 944729422

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2. वही-पृ. 157
3. वही-पृ. 176





परिवर्तन


ISSN 2455-5169
peer-reviewed

साहित्य, संस्कृति एवं सिनेमा की वैचारिकी
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सूचना पट

अंक 14 (अप्रैल-जून 2019, रंगमंच
विशेषांक) के लिए रचनाएँ आमंत्रित हैं।


(0) (1) (2)

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समकालीन कविता में सामाजिक सापेक्षता की अभिव्यक्ति

(नीलेश रघुवंशी के काव्य संकलनों के संदर्भ में)

डॉ. प्रिया ए.

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समकालीन हिन्दी कविता के क्षेत्र में नीलेश रघुवंशी का नाम महत्वपूर्ण है। उनकी कविता में मानवीय जीवन के प्रति संवेदना का स्वर बुलंद होता है। वैश्वीकृत परिवेश में समाज को सकारात्मक ढंग से जीने की ऊर्जा अपनी कविताओं के द्वारा नीलेश रघुवंशी प्रदान करती हैं। हमारे आसपास, दैनिक जीवन के कार्यकलापों को मामूली एवं सहज ढंग से वे अभिव्यक्त करती हैं। नीलेश रघुवंशी की कविताओं में मानवीय मूल्यों की टूटन, आस्था-अनास्था का स्वर, उत्तर-आधुनिक परिवेश से जूझते मनुष्य का तनाव, माँ-पिता-घर जैसे गहरे संवेदनात्मक विषयों को स्थान मिलता है।

उत्तराधुनिक समय में सामाजिक जीवन विसंगतियों एवं अन्तर्विरोधों से भयावह हो उठा है। वैश्वीकरण के चुनौती पूर्ण संदर्भ में कई प्रकार के मानवीय संकटों से आम मनुष्य त्रस्त होता है। "नई सदी" नामक कविता वर्तमान समय के दहशत को प्रस्तुत करती है-

"आतंक और बर्बरता से शुरू हुई नई सदी
धार्मिक उन्माद और बर्बर हमले बने पहचान इक्कीसवीं सदी के
बदा था इक्कीसवीं सदी की किस्मत में
मरते जाना हर दिन बेगुनाह लोगों का
हजार बरसों पीछे ढकेलने का षड्यंत्र! आखिर किया किसने?
किसने? किसने ढकेला जीवन के बुनियादी हकों को हाशिए पर?"¹

Impact Factor-6.261

ISSN-2348-7143

INTERNATIONAL RESEARCH FELLOWS ASSOCIATION'S

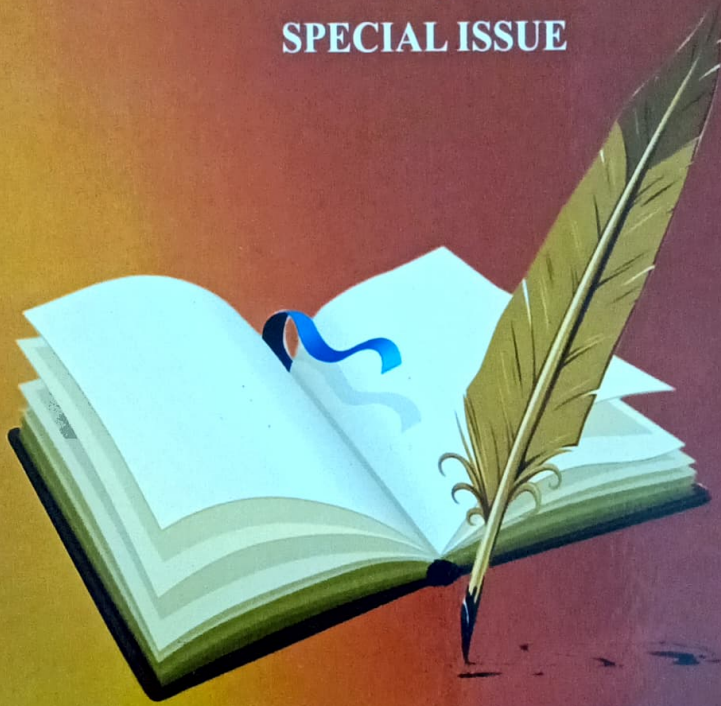
RESEARCH JOURNEY

Multidisciplinary International E-Research Journal

PEER REFREED & INDEXED JOURNAL

February-2019

SPECIAL ISSUE



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Guest Editor

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- University Grants Commission (UGC)
- Scientific Journal Impact Factor (SJIF)
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इक्कीसवीं सदी की कविता में मानवीय संकट का परिदृश्य

डॉ. प्रिया ए.

असिस्टेंट प्रोफेसर

हिन्दी विभाग, के.जी. कॉलेज, पाम्पाडी, कोट्टयम-६८६५०२

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इक्कीसवीं सदी का परिवेश अपसांस्कृतिक विरूपीकरण से युक्त है। समकालीन साहित्य की भाषा मानवीय संकट एवं अपसांस्कृतिक माहौल को दर्ज करती है। विश्व की विभिन्न अर्थ व्यवस्थाओं एवं संस्कृतियों के मेल और एक रूपीकरण ही वैश्वीकरण है। इसकी गिरफ्त में पड़कर पूरी दुनिया एवं पूरा समाज बदल रहा है। विश्व की इस अपसांस्कृति के फैलाव के कारण समूचे साहित्य पर इस युग में नए-नए विषम परिस्थितियों के बादल मंडरा रहे हैं। साहित्य की एक सशक्त विधा कविता के समक्ष भी इस बदलते परिवेश में कई प्रकार के मानवीय संकट उभरते आते हैं। परिस्थितियों के इस परिवर्तित परिवेश में हमारी आज की कविता भी भिन्न प्रकार की चुनौतियों का सामना कर रही है। वैश्वीकरण से उत्पन्न त्रासदियों के कारण आज के युग का मानव जटिल व्यवस्था का शिकार बनकर अपने अस्तित्व को जीवित रखने के लिए कोशिश करता है। अर्थव्यवस्था एवं तकनीकी के गठबंधन उसके सामने आक्रमक एवं जटिल जाल को फैलाकर खड़े हैं। इस चुनौतिपूर्ण परिदृश्य के तहत दबकर मानव मुख्य केन्द्र से दूर हटकर हाशिए पर जाने के लिए विवश होता है। पर कविता ऐसे हाशिएकृत मनुष्य को मुख्य केन्द्र बनाकर ही शब्दबद्ध होती है। अतः समकालीन कविता का मुख्य विषय मनुष्य एवं उससे जुड़ी जीवन व्यवस्था ही है।

डॉ. ए. अरविंदाक्षन की 'कविता के लिए थोड़ी जगह' नामक कविता मानव के संकटग्रस्त माहौल को यों दर्ज करती है-

“बमों से उड़ाए जा रहे वाहनों
और बिखरते माँस के लोथड़ों के बीच
कविताओं के लिए
थोड़ी-सी जगह
क्यों नहीं बची है?
तमाम कवियों से
बस, एक ही सवाल

कविता को कहाँ होना चाहिए?’”^१

प्रस्तुत कविता आधुनिक संकटग्रस्त परिवेश की जायज जायजा प्रस्तुत करती है। कवि ने मानवीय संकट से ग्रस्त दृश्य को दृश्यवत् करने के लिए हिंसा की भाषा का प्रयोग किया है। हिंसा की भाषा के प्रयोग से वे समाज को हिंसात्मक वातावरण के प्रति अवगत कराते हैं- और अहिंसा पूर्ण माहौल की माँग करते हैं। आज का मनुष्य कई प्रकार के संकट ग्रस्त माहौल से घिर कर जीवन बिता रहा है। अहिंसा तत्व को प्रेषित करने वाले भारत में आज सांप्रदायिकता, राजनीतिक ध्वंसता के कारण अशांति या हिंसा का परिवेश व्याप्त हुआ है। ऐसे त्रस्त माहौल में 'कविता को मनुष्य के साथ जुड़कर' उसकी संवेदनात्मक पक्षधरता को संप्रेषित करना है। यही कवि का रचनाकर्म है।

विश्व बाज़ार की विषम परिस्थितियों के बीच सामान्य मनुष्य एवं उसकी भावना कुचल रही है। ऐसी हालत जनमानस, को उसके सोचने-समझने की क्षमता को कुंद करने की साजिश रचती है। तब कवि ऐसे मानव विरोधी राजनीति का प्रतिरोध करता है। वैश्वीकरण दुनिया के सामने बड़े संकट के रूप में उपस्थित है। संकटग्रस्त मानवता में दृढ़ विश्वास भरते हुए समकालीन कवि 'ज्ञानेन्द्रपति' कहते हैं-

“कहना ही होगा हमें
हम प्रलय होने न देंगे

इस सौर मंडल में।”^२

इन पंक्तियों द्वारा वे जनता को चुनौतियों का सामना करने के लिए सचेत करते हैं। विषम परिस्थिति में कवि समाज के लिए एक प्रतिरोध की भाषा गढ़ते हैं। इससे समाज को विरोधी परिवेश में तनकर खड़े होने के लिए नयी ऊर्जा प्राप्त होती है।

साम्राज्यवादी मीडिया सामाजिक सरोकारों को नष्टध्वस्त करता हुआ उपभोग दर्शन के अंधाधुंध प्रचार-प्रसार, संप्रतिष्ठित है। आम जनता के दुःख-दर्द; अभाव और असन्तोष के लिए कोई स्थान नहीं है। बाज़ारवादी व्यवस्था को विकल्पहीन व स्वाभाविक सच्चाई घोषित करते हुए ज्ञानेन्द्रपति लिखते हैं-



॥ श्रम एव जयते ॥

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एक दिवसीय

राष्ट्रीय संगोष्ठी

विषय

इक्कीसवीं सदी के हिंदी कथा साहित्य में चित्रित विविध
विमर्श (सन् 2010 से अब तक)

07 Dec. 2019

संपादक

डॉ.माधव राजप्पा मुंडकर



॥ श्रम एव जयते ॥

दे.भ. बा. भा. खंजिरे शिक्षण संस्था संचलित

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(सन् 2010 से अब तक)

07 Dec. 2019

संपादक

डॉ. माधव राजप्पा मुंडकर



आदिवासी विमर्श के परिप्रेक्ष्य में समकालीन हिंदी कहानी

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इक्कीसवीं सदी तक आते-आते हमारा देश प्रगति के पथ पर निरन्तर अग्रसर हो रहा है। विकास की सीढ़ियों की ओर प्रतिदिन बढ़ता जा रहा है। दुनियाकी तेज रफ्तार में हमारे देश का एक बड़ा समाज मुख्यधारा से अलग होकर जीवन बिता रहा है। विस्थापन का शिकार होकर कराह रहा है। ऐसे विडंबनात्मक माहौल में आदिवासी की चिंता जल, जंगल, ज़मीन, भाषा एवं संस्कृति की है; जो उनकी अस्मिता की आधारशिलाएँ हैं। देश के मूल निवासी माने जानेवाले तमाम आदिम समुदायों का सामूहिक नाम है 'आदिवासी'। आदिवासी विमर्श में आदिवासी समाज के रहन-सहन, उनकी संस्कृति, परम्पराएँ, साहित्य, अस्मिता से जुड़ी समस्याएँ एवं उनके अधिकारों के बारे में विस्तृत चर्चा की जाती है। समकालीन हिंदी कहानियों में आदिवासी जीवन, बदलते परिवेश एवं नवीन संघर्षों और चुनौतियों की अभिव्यक्ति हो रही है।

समकालीन समय में आदिवासी समाज के सामने सबसे बड़ी चुनौती है - विस्थापन की त्रासदी। विकास की योजनाओं के तहत आदिवासी वर्ग की स्वतंत्रता, उनकी बुनियादी ज़रूरतें सब कुछ कुचली जा रही है। विस्थापन के शिकार होकर उन्हें अपनी ज़मीन से, जंगल से बेदखल किया जाता है। अपनी ज़मीन से निर्वासित होकर उन्हें सुदूर महानगरों में जाकर रहना पड़ता है। उनके जीवन में अचानक आनेवाली इस विवशता को, बदलाव को वाल्टर भेंगरा तरुण की कहानी 'संगी' में ओम प्रस्तुत किया है - "आज बड़े-बड़े कारखानों, खदानों और बड़ी-बड़ी योजनाओं के नाम पर यहाँ के आदिवासी उखड़ने और बिखरने लगे हैं। हर रोज़ सैकड़ों आदिवासी यू.पी., दिल्ली, पंजाब, नागालैंड और कर्ना. कर्ना. नहीं रोज़ी-रोटी की तलाश में जा रहे हैं।" आदिवासी जीवन के अनुभवी यथार्थ का चित्रण कहानी के पात्र फागू मुंडा के शब्दों में देख सकते हैं।

भूमंडलीकरण निजीकरण एवं उदारीकरण के दौर में आदिवासियों की तबाही, लूट, शोषण आदि का प्रामाणिक चित्रण हम कहानियों में देख सकते हैं। बाजारीकरण की नीतियों से साम्राज्यवादी ताकतें पूर्ण रूप से जंगल एवं जंगल के संसाधनों पर कब्ज़ा जमा चुकी हैं। प्राकृतिक संसाधनों पर निर्दय रूप से शोषण होने लगा है; फलस्वरूप पहाड़ी इलाकों में कोलियरियां बड़ी मात्रा में पनप रही हैं। इस प्रकार बाहरी ताकतों के हस्तक्षेप से आदिवासी वर्ग का खेत-खलिहान बर्बाद होने लगा है। इस हकीकत को पीटर पॉल एक्का की कहानी 'राजकुमारों के देश में' स्पष्ट करती है - "वहाँ एक नयी कोलियरी खुल गयी थी। जाने गंगा पार के किन देशों से लोग आकर बसने लगे थे। वर्षों की मेहनत से बने-बनाए खेत दब गए थे। मुआजा के नाम मिली रकम गाँव के सरपंच की झोली में चली गयी थी।"²

आदिवासियों की अपनी धरती, कबीलाई संस्कृति आज भी जीवित है। जल, जंगल, ज़मीन तथा खेत-खलिहानों में उनका अधिकार है। पर निजीकरण की प्रक्रिया ने उन्हें अपनी संस्कृति, जड़ों और जीवन शैली से अलग कर दिया। ऐसे वे अपने घर में परदेशी होकर जीवन बिताते हैं। दुर्भाग्यपूर्ण स्थिति में वे स्वत्वहीन होकर यायावर भूमिहीन श्रमिक बन गए हैं।

साम्राज्यवादी ताकतों ने आदिवासियों की मानसीकता पर भी अधिकार जमाया है। उनकी ईमानदारी और मासूमियत का भी सदियों से खूब शोषण हो रहा है। वर्तमान समय में यह शोषण कार्य ज्यादा तेज बन गया है। उनके श्रम और मेहनत का फायदा पूँजीवादी वर्ग को ही मिलता है। ऐसी विकल वास्तविकता को चित्रित करनेवाली कहानी है मंगल सिंह मुंडा की 'धोखा' - इस कहानी में ठेकेदारों के पैसे हड़पने की चाल को सरदार यों व्यक्त करते हैं - "ये ही झारखंड के गरीब आदिवासी। ईश्वर ने इन्हें बड़ी सूझ-बूझ से बनाया है। जो कहो, 'हां' ही में उत्तर देंगे / 'न' कहना तो ये जानते ही नहीं। ईमानदारी की तो ये सजीव मूर्ति है। यही सब कारण है इनके डिमांड का / जिस ठेकेदार के हाथ लगे कि वह चाँदी काटने लगता है, क्योंकि बीस का हिसाब लगाओ और पन्द्रह का भुगतान कर दो / पाँच अपनी जेब में भर लो।"³

अपनी खेती-बाड़ी संस्कृति से अलग होकर, मजदूर बनने के लिए विवश आदिवासियों के श्रम से इन्हीं ठेकेदारों द्वारा अनुचित लाभ उठाया जा रहा है। आदिवासियों के क्षेम के लिए सरकार द्वारा बनायीं जानेवाली योजनाओं का छोटा सा हिस्सा भी उन्हें प्राप्त नहीं होता। सरकार की इस कूटनीति के विरुद्ध पीटर पॉल एक्का की कहानी के पात्र मंगलू काका कूटनीतिज्ञों पर सवाल उठाते हैं कि - "कोलियरी किनके लिए खुली थी, खेत-खलिहान किनके दबे थे, जंगली कंद-मूल, फल-फूल किनके बंद हुए थे, सखुए के उन लहलहाते वनों का क्या हुआ था, उनकी जगह सागवान के पेड़ क्यों लगाए गए थे। गाँव में राजनीति के बेहद धिनोने, फूहड़ भेदे चक्र क्यों चलने लगे थे। पढ़े-लिखे बाबू बेबस भोलेभाते लोगों को बेरहमी से लूटते थे। आए दिन चोरी-डकैती, बलवा, खून होने लगा था। बहू-बेटियां खुले आम किनसे लूटने लगी थी? खुला-खुला खूबसूरत बेफिक्र, अलहड-सा पहाड़ी अंचल क्यों बेहया-सा बेपर्दा किया जाने लगा था?"⁴ इस कथन में आदिवासी जीवन की टूटन के स्वर और प्रकृति और स्त्री के प्रति होनेवाले शोषण के विरुद्ध सवाल किया गया है। तत्कालीन समाज में व्याप्त धिनोनी राजनीति, आदिवासी संस्कृति



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A Cost Effective and Facile Approach to Prepare Beadless Polycarbonate Nanofibers with Ultrafine Fiber Morphology

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Preparing defect free nanofibers with average diameter well below 100 nm is a challenge to researchers by electrospinning technology. In the present contribution, the electrospinning method was utilized to prepare beadless polycarbonate (PC) nanofibers with average diameter 90 nm using comparatively less toxic and suitable solvents in a convenient way. Spinning PC with pure dichloromethane (DCM) and also with 1:1 mixture of DCM and *N,N* dimethylformamide under the same spinning parameters with varying PC concentration has very much helped to establish the effect of solvents on fiber formation. This study also proved the impact of solution concentration, viscosity, and solution conductivity on the formation of beadless ultrafine PC fibers and subsequently on the bead density and average fiber diameter. The appropriate proportion of solvents under suitable spinning parameters has helped to minimize the quantity of PC during the formation of bead free nanofibers by electrospinning. The ultrafine, uniform, and beadless morphology of the electrospun PC fibers can be utilized for various nanotechnology advancements. POLYM. ENG. SCI., 59:1799–1809, 2019. © 2019 Society of Plastics Engineers

INTRODUCTION

Nanotechnology, indeed, the technology of modern world has created a new outlook for synthesizing and developing advanced materials. It is actually the creation and exploitation of materials having structural characters in between that of atoms and bulk materials. The availability of new methods for the synthesis and various tools for their characterization were equally contributed for the boundless growth of nanoscience and technology in the last few years. The exciting transformation of a bulk material into a material with tunable properties during its change into nanomaterials was highly commendable. Nanomaterials with very small size and novel size-dependent properties were highly useful for wide variety of applications in various fields including medicine, biotechnology, electronics, catalysis, environmental, and information technology [1–5]. In recent years, one-dimensional nanofibers have attracted broad attention and have been widely used in many fields due to their unique characteristics such as superior mechanical performance, high specific surface area, and flexibility in surface functionalities. Such exceptional properties cover one-dimensional nanofibers as a highly suitable and inevitable candidate for wide variety of applications [6, 7]. There were different methods for the production of polymer nanofibers such

as self-assembly, mechanical drawing, template synthesis, and electrospinning. However, unfortunately most of the methods have some or other kinds of advantageous and disadvantageous [8, 9]. Among various methods, electrospinning is the simplest and most widely used fiber fabrication method for the mass production of long and continuous nanofibers by the application of a high electric potential [10–13]. The most important features of electrospun polymer fibers were the higher surface area and smaller pore size that enabled them as important materials in many fields such as filters for the separation of submicrometer particles, reinforcing fillers in composite materials, wound-dressing and tissue scaffolding materials for medical uses, controlled release materials for agricultural and pharmaceutical uses, in nanocatalysis, protective clothing, optical electronics, healthcare, chemical sensors, electrode materials, defense, security, and environmental engineering [14–17]. Generally, nanostructured materials were considered as structures with average diameter below 100 nm but electrospun nanofibers with diameters up to 1 μm can be effectively utilized for many purposes. A high DC voltage is necessary to generate the nanofibers through electrospinning and the voltage can be varied to obtain suitable surface morphology [18]. This was first studied and presented by Zeleny in 1914 [19] and patented in 1934 by Formhals [20]. Taylor, in 1964 proved that at a critical voltage, the polymer jet assumes a semivertical angle called Taylor cone from which a stable jet of polymer ejected and move toward the collecting plate [21, 22]. Figure 1 shows an illustration of electrospinning technology showing fiber formation and its schematic representation.

The three major components of an electrospinning system are a high-voltage power supply, a spinneret, and a grounded fiber collecting metal plate. The high voltage source applies charge of a certain polarity into the polymer solution, which in turn accelerated toward the collector of opposing polarity [20, 21]. The polymer solution was taken in a syringe and applied a high voltage at the tip of the needle. The other electrode of the high-voltage power supply was connected to the conductive metal collection plate to complete the circuit. When the applied electric field overcomes the surface tension of the polymer solution, ejection of polymer jet occurs suddenly. Major forces acting on an infinitesimal segment of the charged jet are gravitational force, electrostatic force carrying the charged jet from the tip of the nozzle to the target, columbic repulsion force responsible for the stretching of the charged jet during its flight to the collector, viscoelastic forces that prevent the charged jet from being stretched, surface tension which acts against the stretching of the surface of the charged jet and the drag forces due to the friction among the charged jet and the surrounding air [23]. Due to the combination of these forces, the electrically charged jet travels in a straight trajectory for only a short distance before undergoing a bending instability, which results in the formation of a looping trajectory [24]. The charged jet then thins down and consequently dries out to deposit ultrafine fibers on the metal collecting plate [25]. Fluid jets with Newtonian flow characteristics

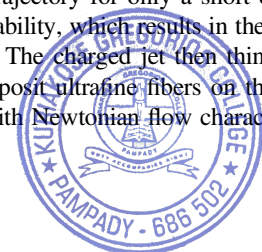
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Contract grant sponsor: KSCSTE, contract grant sponsor: University Grants Commission of India.

DOI 10.1002/pen.25180

Published online in Wiley Online Library (wileyonlinelibrary.com).

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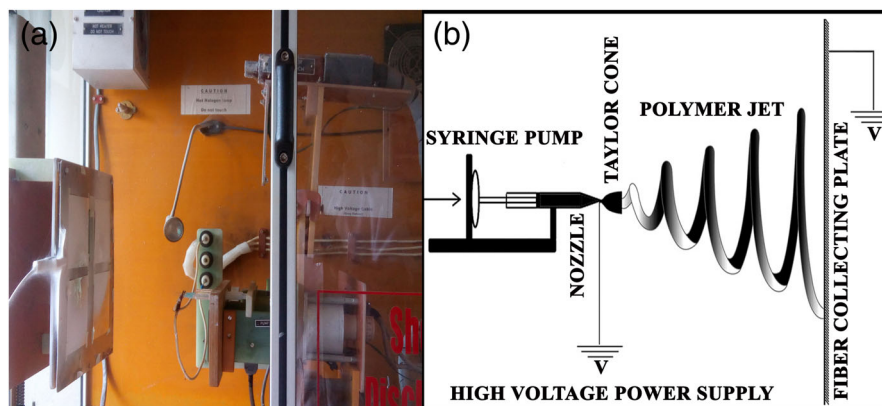


FIG. 1. Electrospinning technology. (a) Fiber formation and (b) schematic representation. [Color figure can be viewed at wileyonlinelibrary.com]

breaks up through Rayleigh instability into drops, but in non-Newtonian fluids, elongation flow resist the breakup of the viscoelastic jet that leads to the formation of long fibers [26, 27]. Applying electric potential to the solution enhances the splitting and splaying of the primary jet into a series of mini jets [28]. Overall diameter was further reduced by the splitting of each mini jets into thinner jets and finally solvent evaporation occurs to form the fibrous structure [29].

Selection of a proper solvent, suitable polymer concentration as well as controlling the intrinsic conductivity, the viscosity, and the surface tension of the solution were the major factors influencing electrospinning [30, 31]. Sufficient intermolecular interactions required for proper chain entanglement were also essential for good surface morphology [32–34]. Large number of spinning parameters can influence the surface morphology of the electrospun polymer fibers. These are categorized into solution parameters, process parameters and ambient parameters like temperature, relative humidity, and velocity of the surrounding air [30, 35]. The increase in the solution viscosity as a result of an increase in the solution concentration was mainly responsible for the increase in the average fiber diameter [36]. There were lots of studies regarding the effects of solution concentration, applied electric field, deposition distance, and deposition time on the morphological characteristics of various synthetic as well as natural electrospun fibers [37, 38]. Even though, the high concentration of a polymer solution supports proper chain entanglement, the resulting high viscosity hinders the smooth functioning of spinning. The balance between solution concentration, surface tension, and viscosity is the key factor for successful electrospinning [39–41].

Poly(bisphenol A carbonate) (PC) (Fig. 2) is an important high performance engineering thermoplastic material with superior optical and mechanical properties that enabled to extend its applications in various day-to-day advancements [42–44].

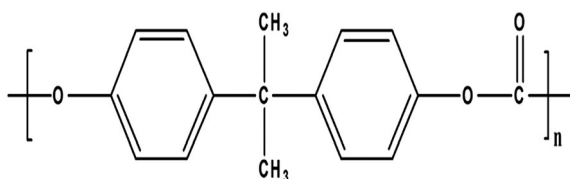


FIG. 2. Poly(bisphenol A carbonate).

In addition to this, PC decorates its position as an important injection molding material due to high impact strength, heat resistance [45], good transparency, processability, good thermal properties, and thermomechanical stability [46–48]. There were lots of intensive works using PC in various forms, but few have chosen electrospinning to produce PC nanofibers and investigated the effect of solvents and process parameters on fiber morphology [49]. Many researchers have prepared PC nanofibers in solvents like THF, CHCl_3 , and *N,N* dimethylformamide (DMF) by electrospinning technology and studied the effect of spinning parameters on fiber morphology [50–55]. In some of the works, various additives were added to reduce the average fiber diameter [56–59]. Li *et al.*, Liao *et al.*, and Yang *et al.* used solvents like CHCl_3 and dichloromethane (DCM) for the preparation of PC nanofibers [52, 58, 60].

The purpose of this research is to prepare beadless ultrafine PC fibers with average diameter well below 100 nm by electrospinning in a cost effective, less toxic, and easy way. In many previous works, PC fibers were prepared using highly toxic volatile solvents and the obtained fibers were nonuniform with large average fiber diameter. Beadless fibers with very small diameters were reported to be obtained at very high solution concentration or by the addition of suitable additives. This work tries to establish the effect of solvents, solution concentration, viscosity, and solution conductivity on the fiber morphology and to find out the optimum conditions required to generate defect free PC fibers with least average diameter.

EXPERIMENTAL

Materials, Method, and Characterization

PC pellets with an average molecular weight of 45,000 g/mol was purchased from Sigma-Aldrich. The solvents DCM and DMF were procured from Merck Chemical Company. All the materials were analytical grade and used without further purification. The solvents and polymer properties are provided in Tables 1 and 2, respectively.

Electrospinning Process

PC solutions with concentrations 6, 8, 10, 12, 14, 16, 18, and 20 w/v % were prepared in pure DCM and also in 1:1 mixture of DCM–DMF by 2 h stirring using a magnetic stirrer. Then, the

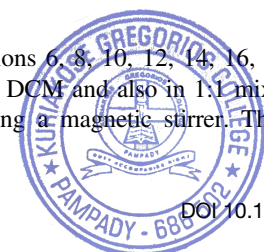


TABLE 1. Properties of solvents DCM and DMF.

Solvent	Boiling point (°C)	Density (g/cm ³)	Viscosity (cP)	Dipole moment (Debye)	Conductivity (μS)	Vapor pressure (kPa)
DCM	39.6	1.33	0.413	1.60	2.33	0.57
DMF	153	0.948	0.802	3.86	5.80	0.38

TABLE 2. Properties of PC.

Density (g/cm ³)	Dielectric constant	Refractive index	Glass transition temperature (°C)	Melting point (°C)
1.21	2.9	1.59	147	155

solution was taken in a 5 mL syringe with $0.6 \times 25 \text{ mm}^2$ needle. All the solutions were electrospun under optimized conditions using ESPIN NANO electrospinning machine supplied by PECO Chennai. In all the experiments, the distance between the tip of the needle and collecting plate was kept constant as 15 cm with a run rate of 0.5 mL/h. A constant electrical potential of 20 kV was applied to the solution at room temperature under the same humidity conditions in a closed chamber. Electrospinning materials were uniformly distributed and collected on an aluminum foil fixed over the collecting plate.

Viscosity and Electrical Conductivity Measurements

The conductivities of PC solutions were measured using CyberScan PC 300 model conductivity meter. The viscosities of PC solutions in pure DCM and in 1:1 DCM and DMF were measured by a Brookfield digital CAP 2000+ viscometer with spindle number 1. The viscosity and solution conductivity values of various concentrations of PC in DCM and in 1:1 DCM–DMF mixture are given in Tables 3 and 4, respectively.

Scanning Electron Microscopy Analysis

The morphology of the electrospun nanofibers was examined and images were taken using TESCAN VEGA 3 SBH scanning electron microscope (SEM) after gold coating the sample using a sputter coater. The average fiber diameter and bead density were measured by analyzing the SEM micrographs with the ImageJ software.

RESULTS AND DISCUSSION

It was already reported a linear relationship between the solution concentration and solution viscosity [61]. The observations were exactly match with various concentrations of PC solutions in

TABLE 3. Viscosity and conductivity of various concentrations of PC in DCM.

Sl. no.	Concentration (w/v %)	Viscosity (cP)	Conductivity (μS)
1	6	8.2	2.25
2	8	31.1	1.82
3	10	32.6	0.42
4	12	33.7	0.38
5	14	90.3	0.21
6	16	120	0.15
7	18	146.8	0.08
8	20	166.5	0.02

TABLE 4. Viscosity and conductivity of various concentrations of PC in 1:1 DCM and DMF.

Sl. no.	Concentration (w/v %)	Viscosity (cP)	Conductivity (μS)
1	6	9.3	4.16
2	8	16.1	3.76
3	10	22.5	3.72
4	12	28.4	3.65
5	14	52.3	3.53
6	16	110	3.22
7	18	176.8	2.98
8	20	253.5	2.70

which solution viscosity increased with increasing solution concentration. However, the viscosity values obtained for PC solutions in pure DCM exhibit marked deviation from the values obtained in 1:1 DCM–DMF mixture. The viscosities of various concentrations of PC in pure DCM were found to be slightly higher at lower concentrations compared to the viscosities of PC in 1:1 DCM and DMF. However, at higher concentrations, PC in 1:1 DCM–DMF mixture shows very high viscosity than in pure DCM. The 20 w/v % concentration of PC in the solvent mixture has a viscosity of 253.5 cP which was only 166.5 cP in the pure solvent. The deviation in viscosities may be attributed to the difference in the fiber entanglement due to various degrees of fiber–polymer interaction on changing the solution concentrations. Comparison of the viscosities of the solutions of various concentrations of PC in pure DCM and in 1:1 DCM–DMF has given in Fig. 3 to supplement the above observations.

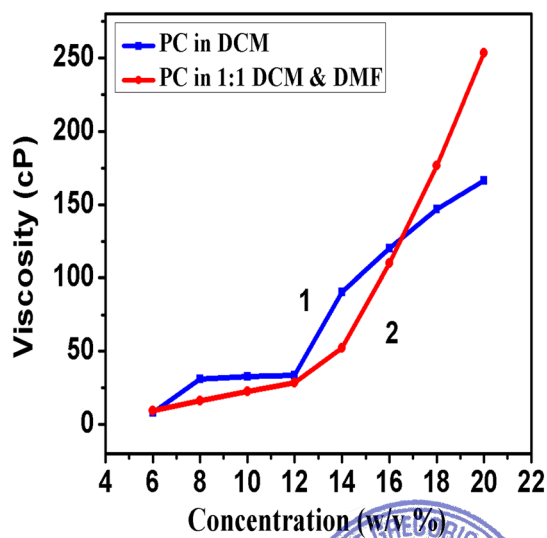


FIG. 3. Comparison of concentration and viscosity of PC in (1) DCM and (2) DCM–DMF mixture. [Color figure can be viewed at wileyonlinelibrary.com]

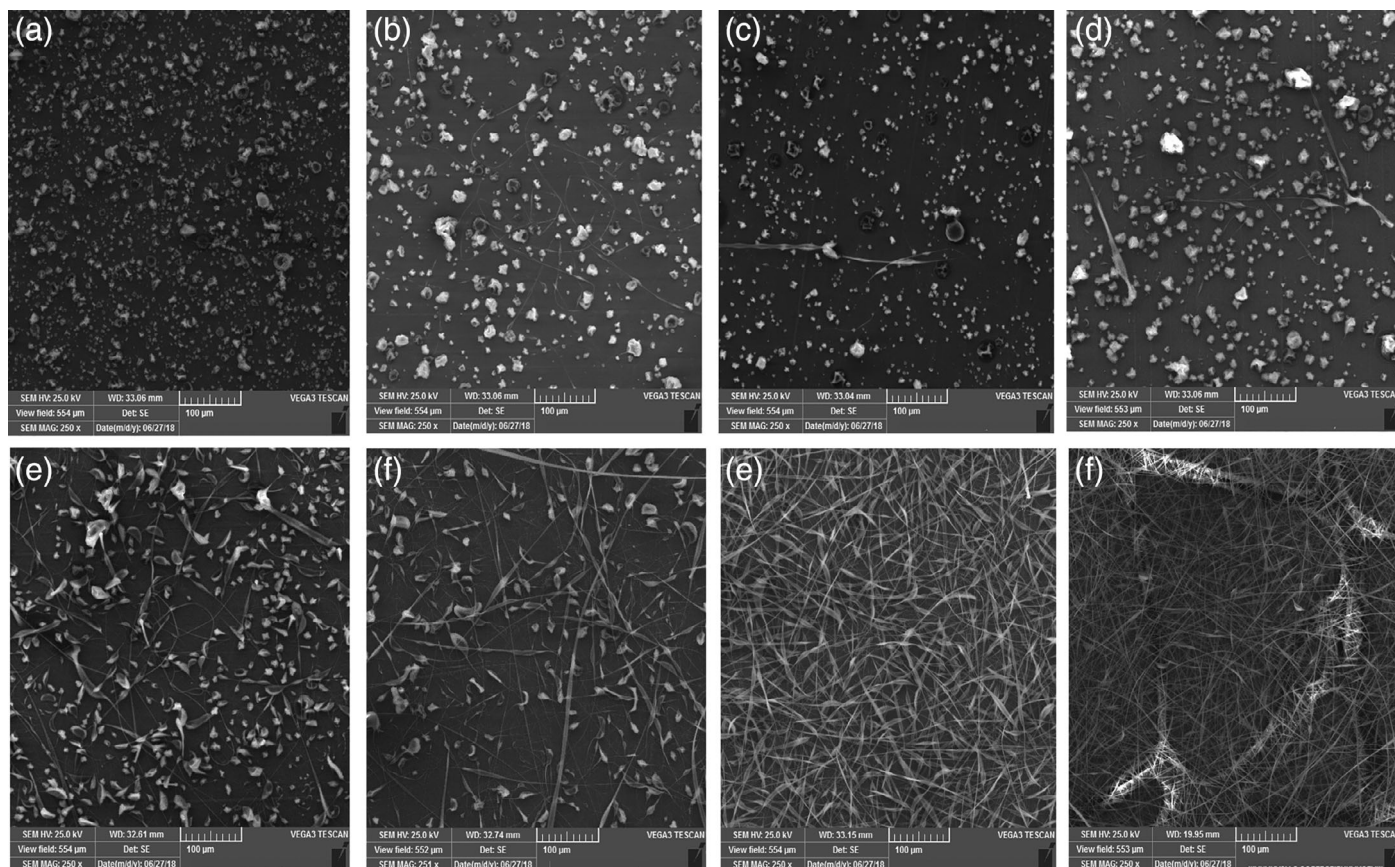


FIG. 4. SEM images of PC in DCM with concentrations (a) 6, (b) 8, (c) 10, (d) 12, (e) 14, (f) 16, (g) 18, and (h) 20 w/v %.

SEM Analysis of PC in DCM

The SEM images of the products obtained by electrospinning of PC strongly support the effect of nature of the solvent, solution concentration, and viscosity on nanofiber fabrication. SEM micrographs of PC fibers obtained from pure DCM with various concentrations from 6 to 20 w/v % are shown in Fig. 4.

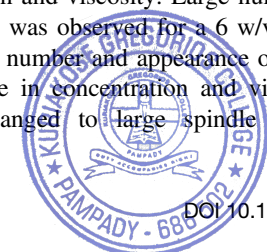
At 6–12 w/v % solution concentrations with viscosities 8.2–33.7 cP, a large number of submicrometer droplets were formed instead of fibers (Fig. 4a–d). At such viscosities, the viscoelastic force due to low degree of chain entanglements in a given jet segment was not large enough to counter the higher Coulombic force, resulting the break-up of the charged jet in to discrete droplets. This phenomenon is called electrospraying and has lot of practical aspects in industries especially in spray painting, ink-jet printing, and powder coating [54, 62, 63]. As the polymer concentration (14 and 16 w/v %) and viscosity (90.3 and 120 cP) increases chain entanglement increases and formation of fibers can be seen along with the droplets (Fig. 4e and f). The fibers obtained were not continuous and the average fiber diameters measured as 418 and 437 nm, respectively. At 18 w/v % (viscosity 146.8 cP) of PC in DCM, highly beaded fibers with diameter ranging from 300 to 1,300 nm with an average diameter of 775 nm were formed (Fig. 4g). At a polymer concentration of 20 w/v % (viscosity 166.5 cP), a dramatic change in the morphology of the fibers observed. Almost uniform fibers with an average diameter of 1,062 nm specify the well-balanced electrospinning

parameters such as viscosity, solution concentration, and applied voltage with surface tension (Fig. 4h). Up to 16 w/v % of PC in pure DCM electrospinning parameters were not favorable for fiber formation under the applied spinning conditions.

SEM Analysis of PC in 1:1 DCM and DMF

SEM images given in Fig. 5 explain the variation of surface morphology of the electrospun fibers with change in the solvent morphology of the electrospun fibers with change in the solvent medium in which the polymer has taken for spinning. The effects of the solvent system on the obtained fibers were investigated by taking PC in various concentrations using the solvent mixture DCM and DMF in the ratio 1:1. A drastic change in the fiber morphology can be observed when the solvent DMF with high dielectric constant was used, in addition to DCM in the previous experiment. As the dielectric constant is a measure of the polarity of solvents, a solvent with high dielectric constant can induce a high net charge density on a solution. The high net charge density of the electrospinning solution is really an advantage for fiber formation.

Beads along with the fibers were observed at concentrations of 6–12 w/v % (Fig. 5a–d), but the number of beads decreased with increase in solution concentration and viscosity. Large number of beads with spherical appearance was observed for a 6 w/v % PC solution (Fig. 5a). However, the number and appearance of beads changed gradually with increase in concentration and viscosity. The large spherical beads changed to large spindle shaped



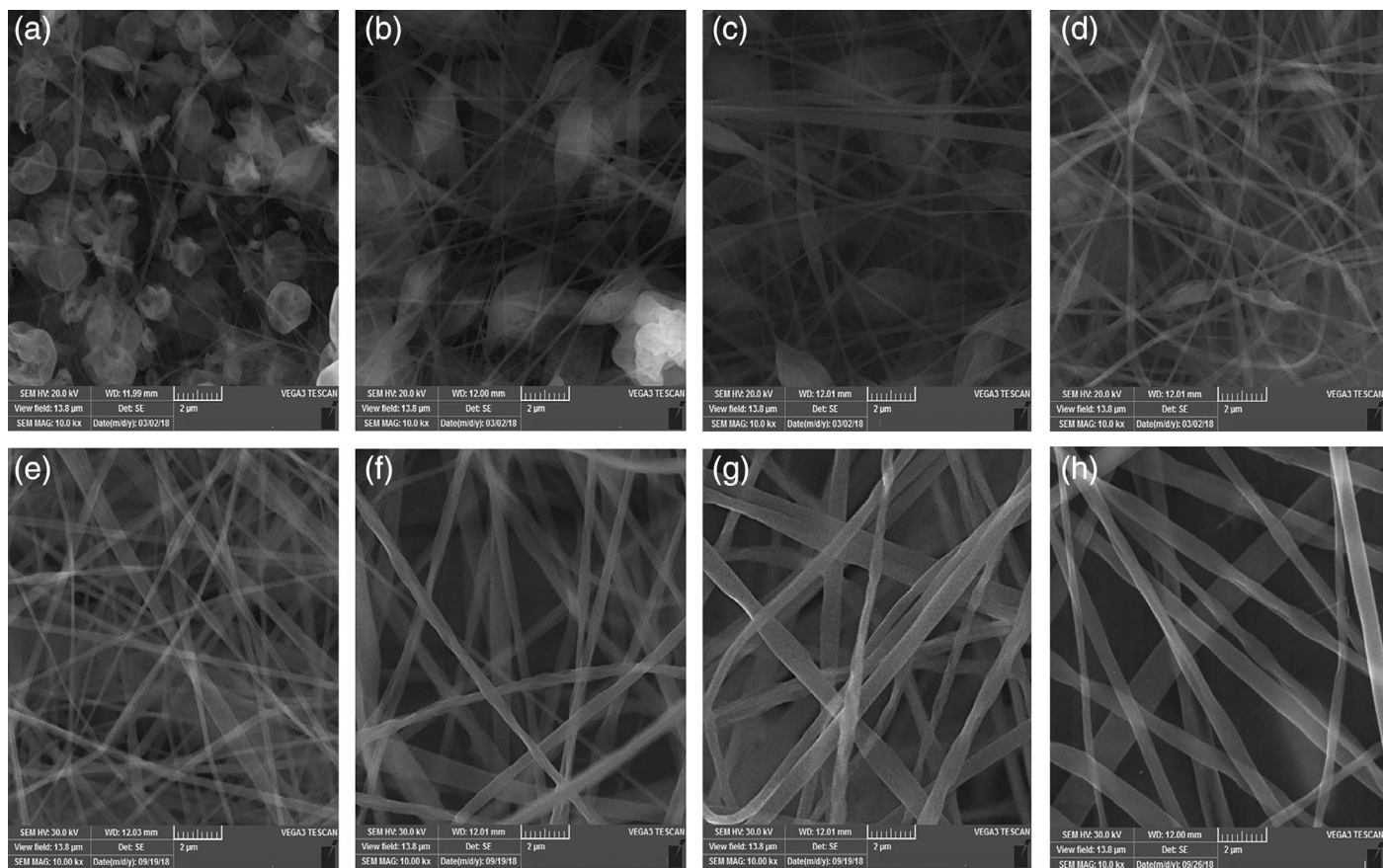


FIG. 5. SEM images of PC in DCM-DMF mixture with concentrations (a) 6, (b) 8, (c) 10, (d) 12, (e) 14, (f) 16, (g) 18, and (h) 20 w/v %.

(Fig. 5b and c) and then to narrow spindle-shaped beads (Fig. 5d). Further increasing the concentration of the PC solution to 14 w/v % with solution viscosity 52.3 cP, transparent and almost uniform fibers with average diameter 90 nm without any beads were formed (Fig. 5e).

At concentrations 16, 18, and 20 w/v % with solution viscosities 110, 176.8, and 253.5 cP, the beads disappeared altogether, leaving only smooth ultrafine fibers on the target (Fig. 5f-h). Fiber morphology again changed at the concentration of 16 w/v % with considerable increase in the average fiber diameter to 382 nm. With further increase in the solution viscosity and concentration, average fiber diameter also increased under the same spinning conditions. Almost uniform transparent fibers with average diameter 551 nm were obtained for 18 w/v % of polymer solution at a viscosity of 176.8 cP. It was slightly difficult to spin the 20 w/v % PC solution due to a high viscosity value of 253.5 cP and fibers with average diameter of 746 nm were produced.

The average diameter of the electrospun fibers was measured using the Image J software and the concentration-average diameter and viscosity-average diameter graphs are given in Fig. 6a-d. In pure DCM defect free fibers were obtained only for a 20 w/v % solution but with a high average fiber diameter. However, for 1:1 DCM-DMF mixture, fibers were produced even for a 6 w/v % solution but defect free fibers obtained for 14 to 20 w/v % of solutions. The average diameters observed for the fibers obtained from 1:1 DCM and DMF for all the solution concentrations were

below 1 μm . These observations of the influence of solution concentration and viscosity on average fiber diameter agree with many literature reports [64, 65].

From all these observations, defect free PC fibers with least average diameter was obtained for 14 w/v % of PC solution in 1:1 DCM-DMF mixture. Figure 7a shows the image of beadless electrospun PC fiber mat with least average diameter obtained by the electrospinning of 14 w/v % PC in 1:1 DCM-DMF mixture and Fig. 7b shows the histogram to support its uniform ultrafine morphology.

In order to confirm the influence of solvents at 14 w/v % PC, other two different proportions of DCM and DMF were also experimented. Then, 14 w/v % of PC in 3:2 and 9:1 DCM-DMF mixtures were prepared and electrospun under the same spinning conditions. The SEM images and the corresponding histograms are shown in Fig. 8a-d.

In both proportions, nonuniform fibers were obtained with average diameters 110 and 298 nm for 3:2 and 9:1 DCM-DMF mixture, respectively. The fiber nonuniformity and average diameter very much increased for PC fibers obtained from a 9:1 DCM-DMF mixture as the DMF part was very less in the mixture. There were very less number of beads, less than 1% in both 3:2 and 9:1 proportions. The solvent DMF has a major role in controlling fiber morphology under suitable solution and spinning parameters.

It was also observed that at a particular concentration, PC in 1:1 DCM and DMF has considerably high viscosity than PC in

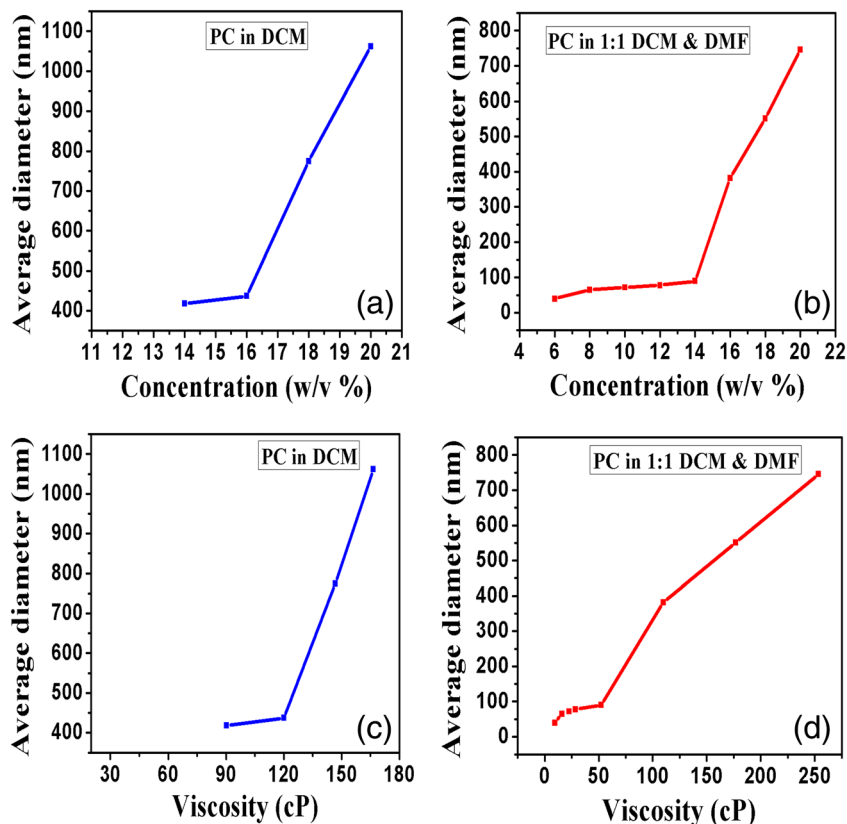


FIG. 6. Graphs showing relation of average diameter with concentration and viscosity of PC (a) concentration-average diameter in DCM, (b) concentration-average diameter in 1:1 DCM and DMF, (c) viscosity-average diameter in DCM, and (d) viscosity-average diameter in DCM and DMF. [Color figure can be viewed at wileyonlinelibrary.com]

pure DCM. Fibers produced from lower concentration and viscosity exhibited more beads keeping all other parameters (flow rate, voltage, distance from the capillary to the target, solvent ratio) a constant. The formation of beads along with the electrospun fibers could be a result of a number of different factors such as visco-elastic relaxation and surface tension [55]. This phenomenon would be possible only when the charged jet was not “dry” before deposition on the collector, causing some parts of the partially

discharged jet to contract and form beads [66]. It was also reported that increase in solvent dielectric constant results a considerable decrease in the bead formation [61, 67–70]. With the help of Image J software, bead density of the prepared nanofibers were measured and the images are given in Fig. 9.

A high contrast SEM image was selected and the software recognized the difference in contrast in the image. With the help of the software, the entire beads were counted and the area of each

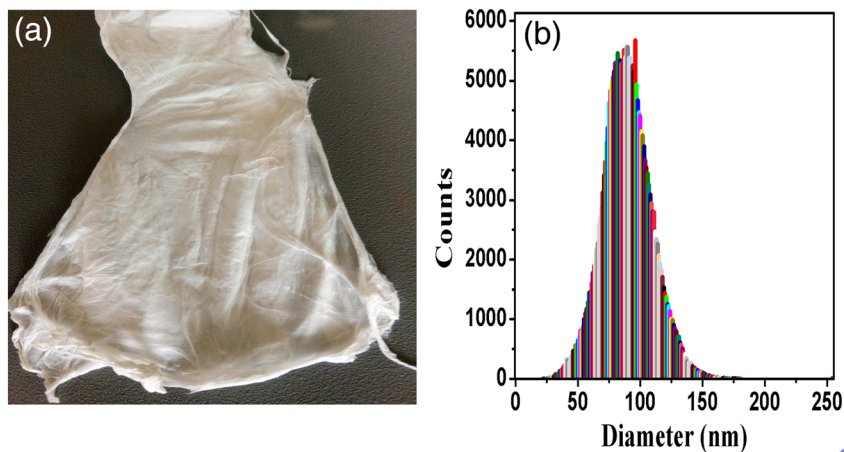
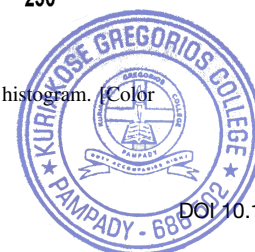


FIG. 7. (a) PC fiber mat obtained for 14 w/v % in 1:1 DCM–DMF mixture and (b) corresponding histogram. [Color figure can be viewed at wileyonlinelibrary.com]



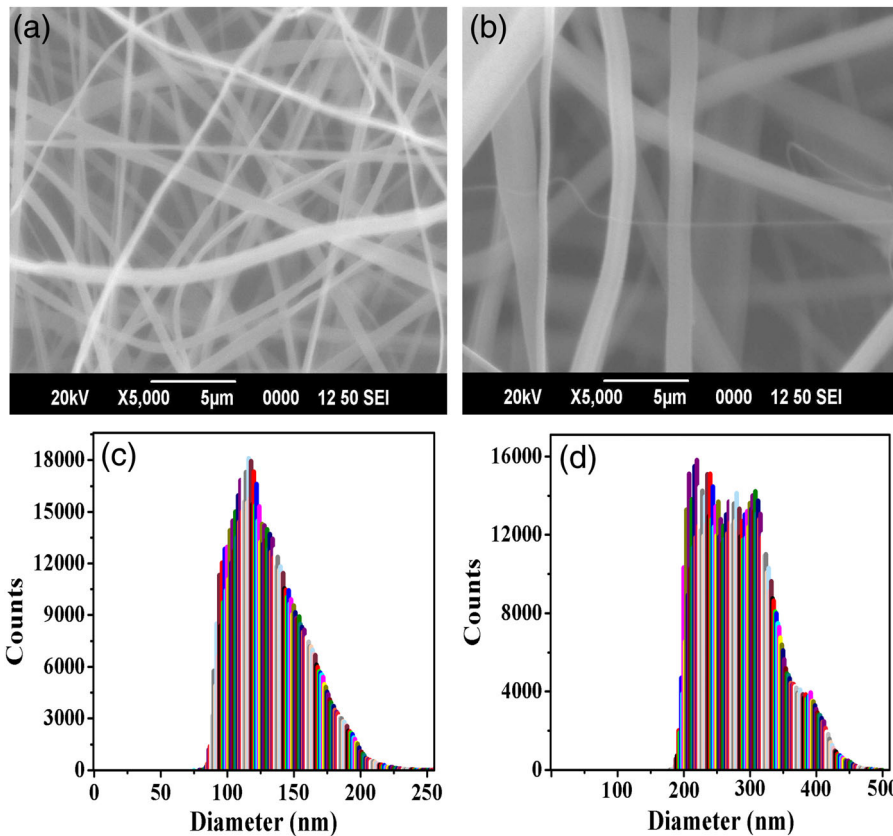


FIG. 8. (a) SEM image of PC fibers in 3:2 DCM and DMF. (b) SEM image of PC fibers in 9:1 DCM and DMF. (c) Histogram of PC fibers in 3:2 DCM and DMF. (d) Histogram of PC fibers in 9:1 DCM and DMF. [Color figure can be viewed at wileyonlinelibrary.com]

bead measured. Then, the bead density was calculated using the formula [49, 71]

$$\text{Bead density} = \frac{\text{Total area of beads in the image}}{\text{Total area of the image}} \times 100$$

Beaded fibers obtained for 6–12 w/v % of PC solutions in the solvent mixture were used for bead density measurement. The bead densities of 6, 8, 10, and 12 w/v % (viscosities 9.3, 16.1, 22.5, and 28.4 cP) of PC in 1:1 DCM and DMF were 42%, 35%, 22.5%, and 4.5%, respectively. Figure 10 is a demonstration of the relationship between solution concentration and viscosity with bead density.

It was observed that the bead density decreased with increase in solution concentration and viscosity. The increase in the solution viscosity and the net charge density opposes the surface tension acting on the jet and beads disappeared gradually [72]. With increase in solution viscosity, spherical beads changed to spindle shaped and bead density decreased to 4.5% for a 12 w/v % solution.

Study of the Influence of Solution Conductivity on PC Fiber Formation

There are only limited number of studies regarding the effect of solution conductivity on the fabrication of nanofibers during

electrospinning. There were few works on the preparation of ultrafine nanofibers by the electrospinning of polymer solutions at lower concentration in which the solution conductivity has been increased by the addition of salts [34]. Solution conductivity very well depends on the nature of the solvent, the type of polymer dissolved, and the entanglement of the polymer in the solution. In the present work, the variation of solution conductivity with polymer concentration and viscosity and thereby the change in the average fiber diameter were studied. Figure 11 has provided a clear idea of the variation of solution conductivities of PC with concentration and viscosity in pure DCM and in 1:1 DCM–DMF mixture.

PC in the solution mixture has higher conductivity than in the pure solvent. There was a sharp decrease in the solution conductivity of PC in DCM by the increase of concentration and viscosity. The solvent DCM has a conductivity of 2.33 μS and the conductivity of PC solutions decreases from 2.25 to 0.02 μS in DCM. A very small value of solution conductivity (0.02 μS) was observed for 20 w/v % of PC solution in DCM. A gradual decrease in solution conductivity from 4.16 to 2.70 μS has been observed for the solution of PC in 1:1 mixture of DCM and DMF, in which the solvent DMF has a solution conductivity of 5.80 μS. There was a considerable solution conductivity of 2.70 μS even for 20 w/v % polymer solution in the solvent mixture. Figure 12 shows the relation between the average diameters of the PC fibers with solution conductivities of PC in pure

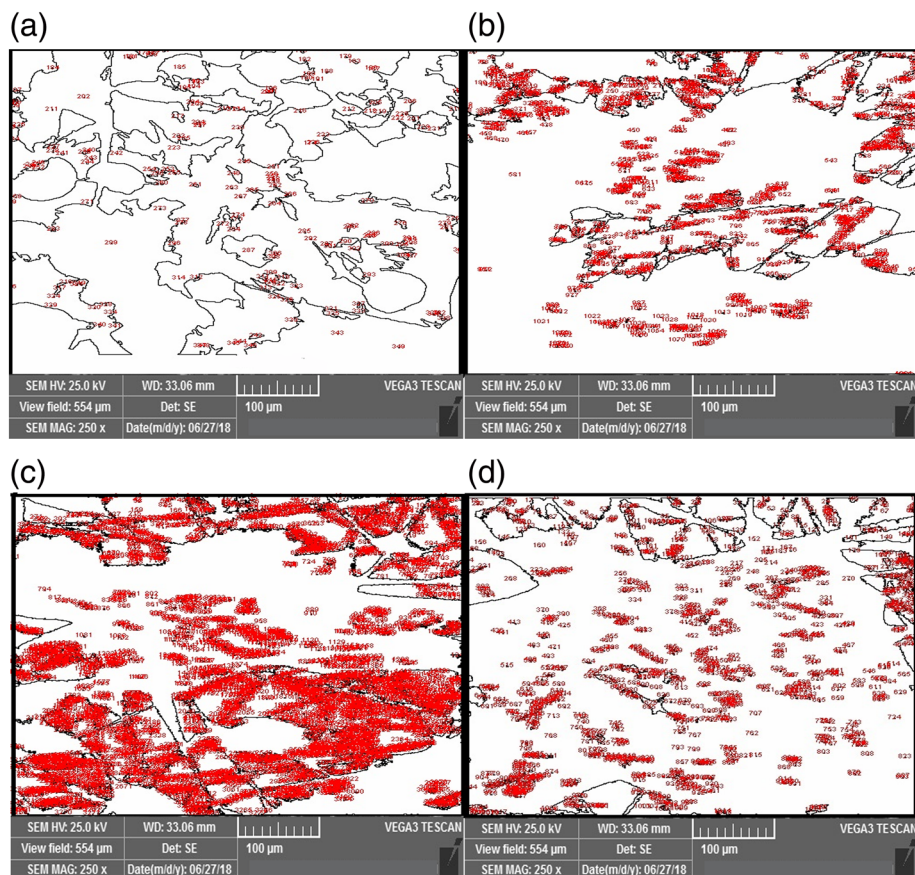


FIG. 9. Bead density images of PC in 1:1 DCM and DMF with concentrations (a) 6, (b) 8, (c) 10, and (d) 12 w/v %. [Color figure can be viewed at wileyonlinelibrary.com]

DCM and in 1:1 DCM–DMF mixture. PC solutions with concentrations 14, 16, 18, and 20 w/v % with conductivities 0.21, 0.15, 0.08, and 0.02 cP in pure DCM has produced fibers with average diameters 418, 437, 775, and 1,062 nm, respectively. At the same time, PC in 1:1 DCM–DMF mixture has produced fibers in the

entire concentration range with corresponding conductivity values from 2.25 to 0.02 cP.

Solution conductivity alone shows little influence on fiber formation and on the average diameter of the fiber, but along with other parameters, it has an influence indeed.

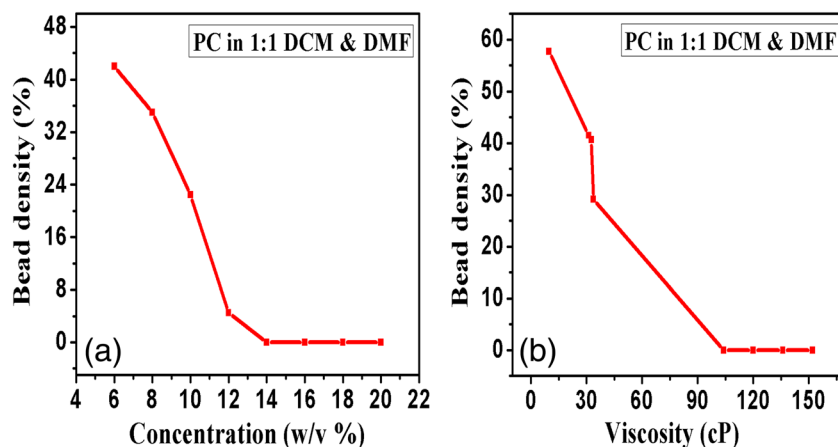
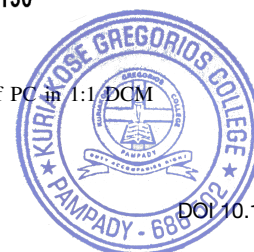


FIG. 10. The relationship between (a) concentration–bead density and (b) viscosity–bead density of PC in 1:1 DCM and DMF. [Color figure can be viewed at wileyonlinelibrary.com]



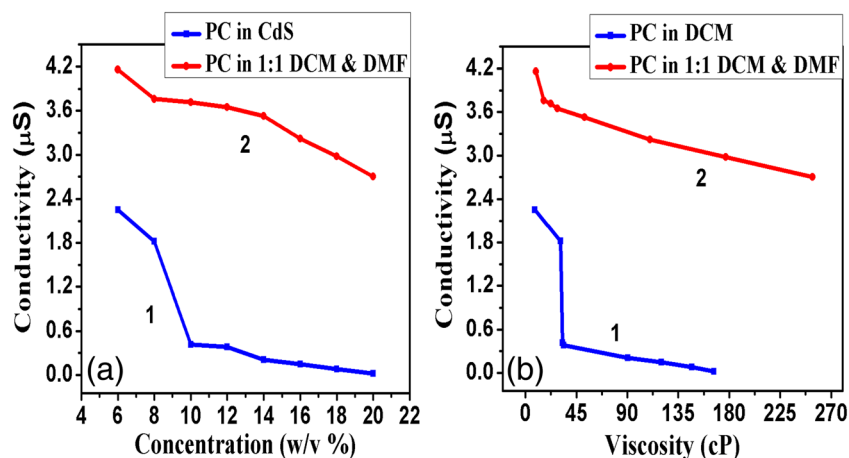


FIG. 11. Comparison of (a) concentration and conductivity of PC in (1) DCM and (2) 1:1 DCM and DMF and (b) viscosity and conductivity of PC in (1) DCM and (2) 1:1 DCM and DMF. [Color figure can be viewed at wileyonlinelibrary.com]

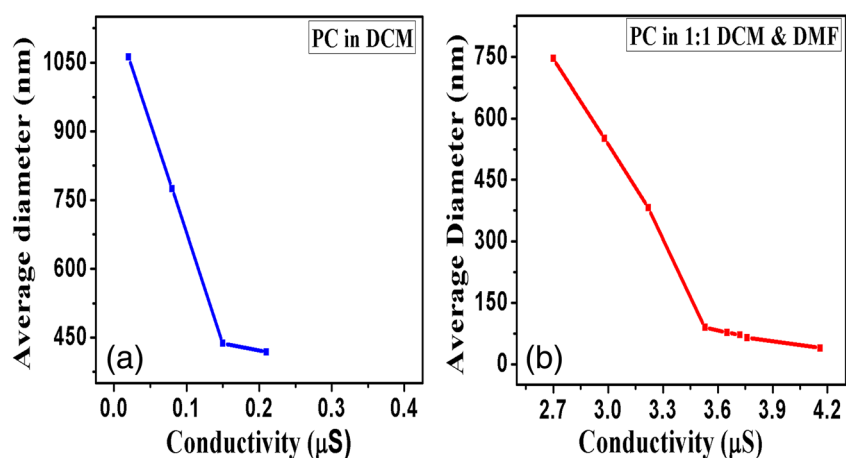


FIG. 12. The graph showing the relationship between conductivity and average fiber diameter of different concentrations of PC in (a) DCM and (b) 1:1 DCM and DMF. [Color figure can be viewed at wileyonlinelibrary.com]

CONCLUSIONS

The present work established a novel, cost effective, less toxic, and convenient method to prepare beadless ultrafine PC fibers in a systematic way. Beadless PC fibers with average diameter 90 nm were obtained even at 14 w/v % concentration which has helped to reduce the amount of PC used in electrospinning which was not at all reported elsewhere. The study carried out in a systematic manner has highly helped to establish the conditions for predicting and tuning fiber morphology based on the type of solvents, solution concentration, and viscosity. There was a marked increase in the solution viscosity on increasing the solution concentration in the pure solvent as well as in the solvent mixture. The solvent DCM with low dielectric constant, boiling point, and dipole moment has the ability to generate PC fibers only at very high solution concentration and viscosity. It was obvious that the fibers obtained by the electrospinning of PC in 1:1 DCM and DMF exhibited exciting morphological changes than in pure DCM even at lower concentration and viscosity. The solvent DMF with high dielectric constant and dipole moment has great influence on the fiber formation and overall morphology of electrospun fibers. The average diameter of the electrospun PC fibers increased with increase in the solution concentration and

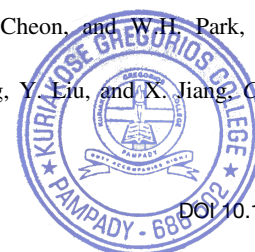
viscosity in the solvent mixture. The beads were totally disappeared at a solution concentration of 12 w/v % in 1:1 DCM and DMF. The optimum concentration and viscosity of the polymer solution in a suitable proportion of solvents has helped to get defect free ultrafine fibers through proper polymer entanglement and further stretching. The present contribution vividly established that the formation of beadless ultrafine fibers was the resultant of the influence of nature of solvents, solution concentration, viscosity, conductivity, applied voltage, flow rate, and the needle tip-metal plate distance. These controlled parameters can be effectively applied to the design of electrospinning methodology for other synthetic as well as natural polymers. Enhanced understanding of these fiber formation mechanisms provides better control of fiber morphology in order to fabricate ultrafine fibers with improved properties for various applications.

ACKNOWLEDGMENTS

The authors acknowledge University Grants Commission of India for granting a minor project and KSCSTE for the financial support to purchase the electrospinning machine.

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A new approach for the shaping up of very fine and beadless UV light absorbing polycarbonate fibers by electrospinning



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ARTICLE INFO

Keywords:

Electrospinning
Taylor cone
Splaying
Beaded fibers
Electrospinning

ABSTRACT

An innovation will be recognized as successful only if it satisfies all phases of product development; i.e. from the specification to mass production. Therefore, a cost-effective production by keeping the best possible characteristics is vital in any industry. Large scale production of polymer fibers with ultrafine morphology is such a challenge to the field of nanotechnology. The idea proposed here utilizes the versatile electrospinning technology for the preparation of uniform, beadless and ultraviolet light absorbing polycarbonate (PC) nanofibers. The average diameter limits to 114 nm and that too by using most convenient and comparatively less toxic solvent mixture. This method is simple and so far, it is not reported elsewhere. For THF-DMF system a PC concentration of 17 w/v% and for DCM-DMF system a PC concentration of 15 w/v% was found to be the optimum polymer concentration. The average fiber diameter and bead density were very much influenced by the viscosity, conductivity and concentration of the solution used for electrospinning. The PC fibers (PC concentration of 15 w/v % in DCM-DMF system) with lowest average diameter of 114 nm shows excellent ultraviolet absorption, semicrystalline nature, enhanced glass transition temperature and thermal stability.

1. Introduction

Nanotechnology, one of the highly recognized and growing technology today has wide variety of leading applications in medicine, biotechnology, air filtration, energy production, food packaging and so on. The various nanostructures produced are significant because of their inherent properties such as large surface area to volume ratio, porosity, stability and permeability [1–4].

Poly (Bisphenol A carbonate) with a general tag polycarbonate (PC) is a prominent engineering high performance polymer with excellent properties like chemical resistance, electrical resistance, mechanical strength, impact resistance, lightweight, transparency, rigidity, toughness, moisture absorption capability, good visual clarity and heat resistance [5]. This has branded PC a material for wide variety of applications such as bullet proof transparent windows, compact disc, digital video disc, electronic equipment, sports safety equipment, medical devices, load bearing items, armored vehicles, rail cars, architects etc. In majority of these applications PC is used in bulk form by molding into particular shape and size [6–8].

Nanoscaled materials can be reasonably designed to exhibit novel

and significantly improved physical, chemical, and biological properties because of their tunable size dependent properties. The major processing techniques used for the production of nanofibers include template synthesis, drawing, phase separation, self-assembly and electrospinning [9–13]. Among these methods, electrospinning is the simplest, cost effective and versatile technique for the mass production of nano to micro sized fibers with minimal use of materials by applying a high electric potential [14–16]. It can produce ultrafine polymer fibers exhibiting high surface area-to-volume and length-to-diameter ratio and are essential for various advanced applications including air and water filtration, bio-medical field, electronics, energy storage, health-care, environmental engineering and defense [17–20]. An electrospinning system consists of a needle as anode, fiber collecting metal plate as cathode, a high voltage power supply that helps to transfer the polymer jet onto the collecting plate and an injection system to supply polymer at a constant flow rate in the orders of few microns to milliliters. Taylor cone, the phenomenon that influences the formation fibers can be observed as soon as the solvent ejected out of the needle by overcoming surface tension [21–23]. The splitting of the primary jet into a number of mini jets called splaying is another important phenomenon that also

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<https://doi.org/10.1016/j.polymeresting.2019.106103>

Received 15 May 2019; Received in revised form 18 August 2019; Accepted 7 September 2019

Available online 07 September 2019

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influence fiber morphology [16,24].

One of the discrepancy observed during electrospinning is the formation of droplets of polymers by capillary breakup of the electrically driven spinning jet. The so called electrospinning phenomenon is usually observed in low viscosity polymer solutions [25–27]. Another trouble commonly encountered is the formation of large bulged mass called beads formed along with the fibers. This is the resultant of various factors including solution concentration, viscosity, surface tension, dielectric constant of the solvent and the net charge density carried by the electrospinning jet [28–31]. The morphology of fibers prepared by electrospinning strongly depends on the solution parameters, process parameters and surrounding conditions. These parameters include solution concentration, viscosity, dielectric constant of the solvents, surface tension, conductivity of the solution, spinning distance, flow rate, applied voltage, humidity and ambient temperature which affect formation of uniform ultrafine and bead free fiber formation [32–34]. The solvent used has an equally important role for the production of ultrafine fibers as it affects the surface tension and the evaporation process of the polymer solution. The intermolecular interaction among the solvent molecules and the polymer macromolecules is the most important factor that affect the solution properties. The major challenge that is being encountered in electrospinning is the optimization of these parameters to achieve desirable nanofiber morphology and properties. The solution concentration, viscosity and fiber diameters are linearly connected [35,36]. By adjusting the spinning conditions, submicron to nanoscale fibers can be prepared by selecting a proper solvent and polymer concentration as well as controlling the intrinsic conductivity, viscosity and surface tension of the solution [37–40]. Numerous works were reported on the preparation of various polymer nanofibers but only few in the case of PC by electrospinning. Different solvent systems and the average diameter of the prepared PC fibers reported by various researchers are given in Table 1.

The above table clearly reveals that the previously reported bead free PC fibers have an average diameter above 1 μm without adding any additives. Hence it can be conclusively stated that preparation of bead-free and uniform nanofibres with diameters nearer to 100 nm by electrospinning still remains a great challenge. In the present work authors have prepared PC nanofibers of average diameter of 114 nm with ultrafine beadless morphology by using an appropriate combination of solvents. An optimum condition was developed by electrospinning various concentrations of PC in 1:1 THF-DMF and 1:1 DCM-DMF mixture. The solution concentration, viscosity and conductivity of the polymer solution have shown great influence on fiber diameter as well as on bead density and has been demonstrated elaborately in the current work. The fiber samples collected after electrospinning were characterized by various sophisticated instrumental techniques.

Table 1
Various works on the preparation of PC fibers in different solvent systems.

Sl. No.	Solvent system	Average fiber diameter	Reference
1	In THF and DMF solvent mixture	Studied the effect of various parameters on morphology	41
2	7:3 THF-DMF with hexa-decyltrimethylammonium bromide (CTAB)	500 nm	42
3	3:2 mixture of THF-DMF	150–200 nm	43
4	CHCl_3 and THF/DMF	Approx. 400 nm	44
5	1:2 and 7:4 THF-DMF mixture	Above 400 nm	45
6	CHCl_3 and THF-DMF mixture	250 nm	46
7	Various Concentrations of PC in DCM, CHCl_3 and THF	221–4314 nm	47
8	Benzyl triethylammonium chloride (BTEAC) in CHCl_3	Above 1000 nm	48
9	Cetane trimethyl ammonium bromide in CHCl_3	Viscosity study	49
10	In CHCl_3 with and without additives	Above 700 nm	50
11	CHCl_3 and in THF-DMF mixture	150 nm - 3 μm	51

2. Experimental

2.1. Materials

Poly (Bisphenol A carbonate) (PC) pellets with average molecular weight of 45,000 g/mol, density 1.2 g/mol at 25 °C and refractive index 1.585 was purchased from Sigma-Aldrich, USA. The solvents dichloromethane (DCM), tetrahydro-furan (THF) and N, N dimethyl formamide (DMF) were procured from Merck India. All the chemicals were analytical grade and used without further purification. The physical properties of the solvents used are given in Table 2.

2.2. Method of preparation

PC solutions with concentrations 7, 9, 11, 13, 15, 17, 19 and 21 w/v percentages in 1:1 THF-DMF and 1:1 DCM-DMF mixtures were prepared separately under 2 h stirring at room temperature. Espin nano electrospinning instrument supplied by PECO Chennai was used for the electrospinning of the prepared PC solutions. Fixed electrospinning conditions were applied for all PC solutions after optimization which includes, a distance of 15 cm between the tip of the needle and collecting plate, a 5 mL syringe with 0.6 \times 25 mm needle, a run rate of 0.5 mL/h and a constant electrical potential of 20 kV under room temperature. An aluminum foil fixed at the metal collecting plate was used for collecting the electrospun materials. Various components of electrospinning machine and the formation of nanofiber mat are shown in Fig. 1.

2.3. Characterization

The conductivities of various concentrations of the PC solutions and pure solvents were measured with the help of Eutech instruments Cyberscan PC 300 model conductivity meter. The solution and solvent viscosities were determined by a Brookfield digital viscometer CAP 2000 with spindle number 1. The surface morphology of the electrospun materials were studied by TESCAU VEGA 3 SBH scanning electron microscope (SEM) instrument after gold coating using a sputter coater. The average fiber diameter and bead density were measured by analyzing SEM images using Image J custom code image analyzing software. Characterization of bead free PC fibers with least average diameter was done by using Rigaku miniflux 600 instrument for X-ray diffraction studies (XRD), Agilent Technologie Carry 5000 UV-Visible spectrophotometer for absorption studies, SPECTRUM 400 instrument for FT-IR analysis and TA differential scanning calorimetric instrument Germany, for thermal studies. The tensile studies were done using AG-X 10 KN Shimadzu Universal Testing Machine. Perkin Elmer STA 6000 instrument was used for thermogravimetric analysis (TGA).

3. Results and discussion

Measurement of various solution parameters are essential for



Table 2
Properties of solvents DCM, DMF and THF at room temperature.

Solvent	Boiling point (°C)	Density (g/cm ³)	Viscosity (cP)	Dipole moment (Debye)	Conductivity (μS)	Vapor pressure (kPa)	Dielectric constant
DCM	39.6	1.33	0.413	1.60	2.33	53.3	8.93
DMF	153	0.948	0.802	3.86	5.80	0.51	36.7
THF	66	0.889	0.456	1.63	2.25	23.46	7.6

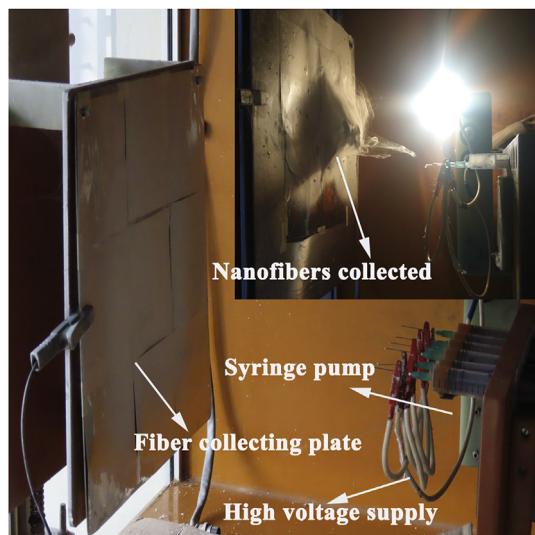


Fig. 1. Electrospinning set up with formation of PC nanofibers (inset).

Table 3
Viscosity and conductivity values of PC in 1:1 THF-DMF mixture.

Concentration (w/v %)	Viscosity (cP)	Conductivity (μS)
7	3.4	6.95
9	8.8	6.35
11	15.8	5.92
13	27.4	5.45
15	46.5	5.26
17	60.6	4.92
19	86	4.65
21	152.2	2.68

Table 4
Viscosity and Conductivity values of PC in 1:1 DCM-DMF mixture.

Concentration (w/v %)	Viscosity (cP)	Conductivity (μS)
7	9.8	4.02
9	17.3	3.81
11	23.1	3.58
13	29.8	3.52
15	59.2	2.99
17	121.1	2.81
19	184.5	2.55
21	261.2	2.48

comparing the surface morphology of the fibers produced. Concentration, viscosity and conductivity values of different concentrations of PC solutions in 1:1 THF-DMF and 1:1 DCM-DMF mixtures are provided in Tables 3 and 4.

Even though concentration and viscosity are directly related, the variation in viscosity of different concentrations of PC in the two different solvent mixtures displayed a very interesting trend (Fig. 2).

Significant variation in viscosity can be observed for various concentrations of PC in 1:1 THF-DMF mixture. For every 2% increase in concentration of the PC solution, viscosity was found to be double its value. Viscosities at higher PC concentrations are also very large due to

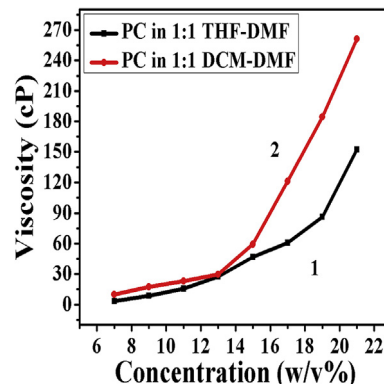


Fig. 2. Concentration-viscosity graph of PC in (1) 1:1 THF-DMF and (2) 1:1 DCM-DMF mixture.

increase in polymer entanglement [52]. There is a gradual increase in viscosity of various concentrations of PC in 1:1 DCM-DMF mixture. Viscosities of 17, 19 and 21 w/v percentages are comparatively much higher than that of PC in 1:1 THF-DMF mixture. This suggests a remarkable difference in the degrees of PC entanglement in different solvent mixtures. This difference in viscosities of the two solution mixtures significantly affects the surface morphology including average fiber diameter and bead density of the electrospun PC fibers. It was reported that solvent with high dielectric constant has a tendency to reduce bead formation in polymer nanofibers [53,54]. A solvent with large dielectric constant has a higher net charge density in the solution. DMF has a large dielectric constant value of 36.7 which consequently affects bead and droplet formation.

[25,38]. A detailed study on the SEM images of the electrospun fibers was sufficient to explain the relation between average fiber diameter and bead density with concentration, viscosity and conductivity of the PC solutions.

The average diameter and percentage bead densities of the prepared nanofibers were measured with the help of Image J software by selecting a high contrast SEM image. From the total area and area of the beads, the bead density was calculated using the formula [31,43],

$$\text{Bead density} = \frac{\text{Total area of beads in the image}}{\text{Total area of the image}} \times 100$$

PC in the two different solvent mixtures has produced nanofibers with different surface characteristics.

3.1. SEM analysis of PC in 1:1 THF-DMF mixture

A detailed investigation of the SEM images of electrospun PC fibers obtained by the electrospinning of various concentrations of PC in 1:1 THF-DMF mixture vividly establishes the role of solvents, solution viscosity and concentration on fiber formation (Fig. 3).

7, 9, 11, 13 and 15 w/v percentages solutions (Viscosities 3.4, 8.8, 15.8, 27.4 & 46.5 cP) of PC have produced beaded fibers with average fiber diameters of 89, 102, 118, 180 and 327 nm respectively. A 7 w/v % PC solution upon electrospinning has produced highly beaded fibers with a bead density of 71% (Fig. 3(a)). Bead densities of 9, 11, 13 and 15 w/v percentages of PC solutions were 63.54, 47, 38.5 and 5.45 percentages respectively. A combination of spherical and spindle

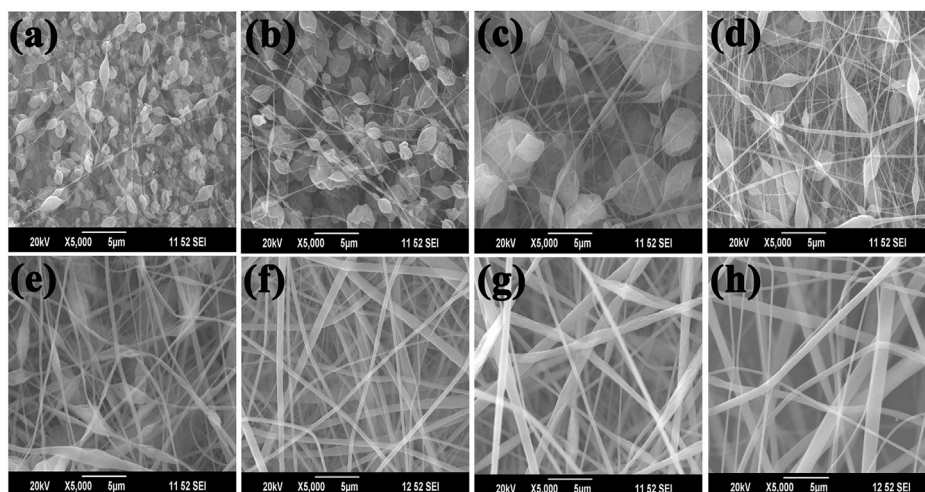


Fig. 3. SEM images of PC nanofibers obtained from 1:1 THF-DMF mixture (a) 7 w/v% (b) 9 w/v% (c) 11 w/v% (d) 13 w/v% (e) 15 w/v% (f) 17 w/v% (g) 19 w/v% and (h) 21 w/v%.

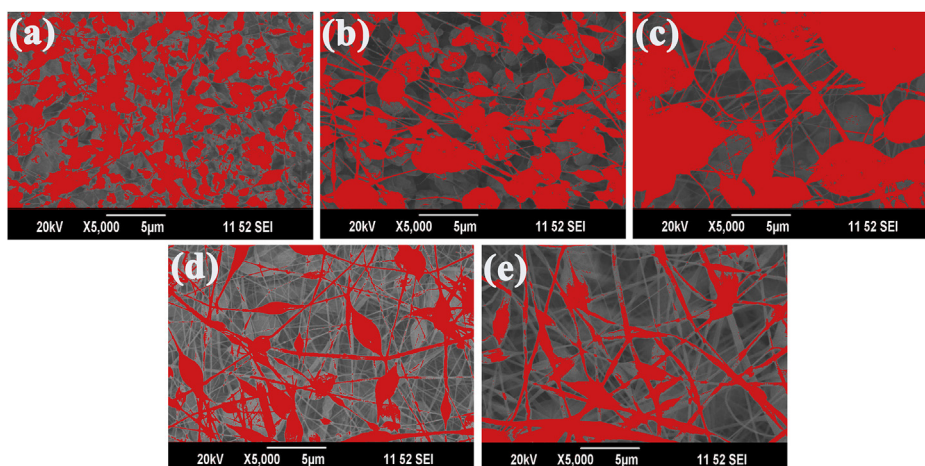


Fig. 4. Bead density images of PC nanofibers obtained from 1:1 THF-DMF mixture (a) 7 w/v % (b) 9 w/v % (c) 11 w/v % (d) 13 w/v % and (e) 15 w/v %.

shaped beads can be seen at lower concentration and it became thin spindle shaped at higher concentrations (Fig. 3(a–e)). The beads completely disappeared at concentrations 17, 19 and 21 w/v percentages (Fig. 3(f–h)). The bead density images obtained by using Image J software clearly establish the gradual change in the number and appearance of the beads as shown in Fig. 4(a–e).

Fibers produced from solution with low concentration and viscosity exhibited more beads upon keeping all other parameters (flow rate, voltage, distance from the capillary to the target and solvent ratio) a constant. The formation of beads along with the electrospun fibers could be a result of a number of different factors as discussed earlier. The concentration-bead density and viscosity-bead density graphs also confirm the decrease in bead density with increase in solution concentration and viscosity (Fig. 5).

Bead free fibers with average diameters of 524, 863 and 1180 nm were obtained for 17, 19 and 21 w/v percentages (viscosities 60.6, 86 and 152.2 cP) of PC solutions. Formation of beadless fibers was due to the balance between various electrospinning parameters like viscosity, concentration and applied voltage with surface tension. The histograms of the electrospun fibers support the results obtained from SEM analysis (Fig. 6). The variation in average diameter and fiber uniformity can be clearly identified from the histograms provided. Average fiber diameter increases with increase in concentration of the PC solution. Uniformity of the fibers produced decreased at higher concentrations (Fig. 6(g) and (h)).

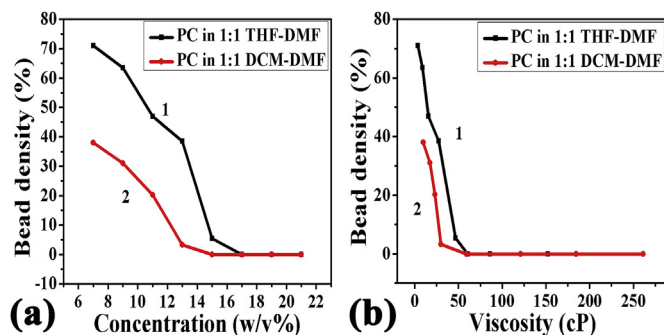


Fig. 5. a) Concentration-bead density graph (1) 1:1 THF-DMF and (2) 1:1 DCM-DMF b) Viscosity-bead density graph (1) 1:1 THF-DMF and (2) 1:1 DCM-DMF mixture.

Surface plot image obtained from a highly contrast SEM image is another tool to know the surface irregularity of a material. The x, y and z axes represent the length, breadth and height of the SEM image under examination. Fig. 7 depicts the surface plot images of the PC nanofibers obtained by the electrospinning of various concentrations of PC in 1:1 THF-DMF mixture. It confirms the increase in non-uniformity of the nanofibers with increase in solution concentration. The deviation is high for the nanofibers obtained from 19 to 21 w/v percentages of PC

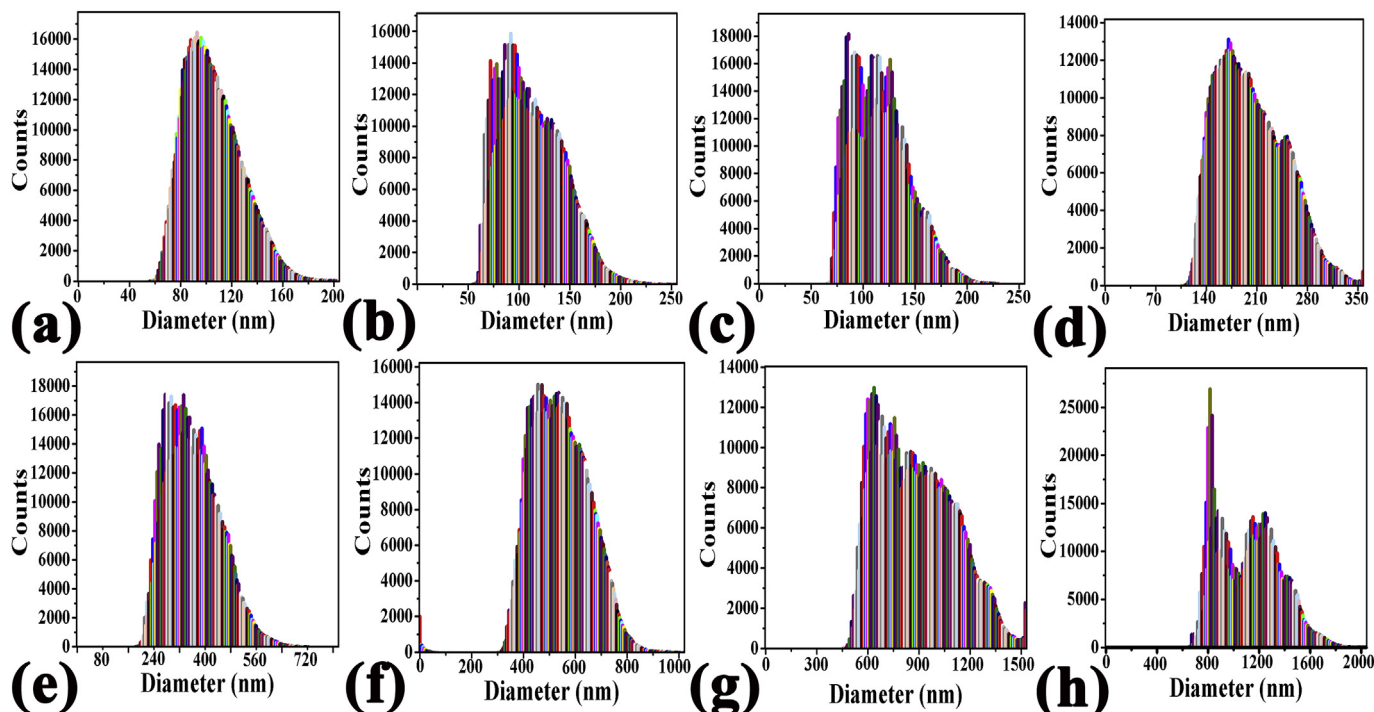


Fig. 6. Histograms of PC nanofibers obtained from 1:1 THF-DMF mixture (a) 7 w/v% (b) 9 w/v% (c) 11 w/v% (d) 13 w/v% (e) 15 w/v% (f) 17 w/v% (g) 19 w/v% and (h) 21 w/v%.

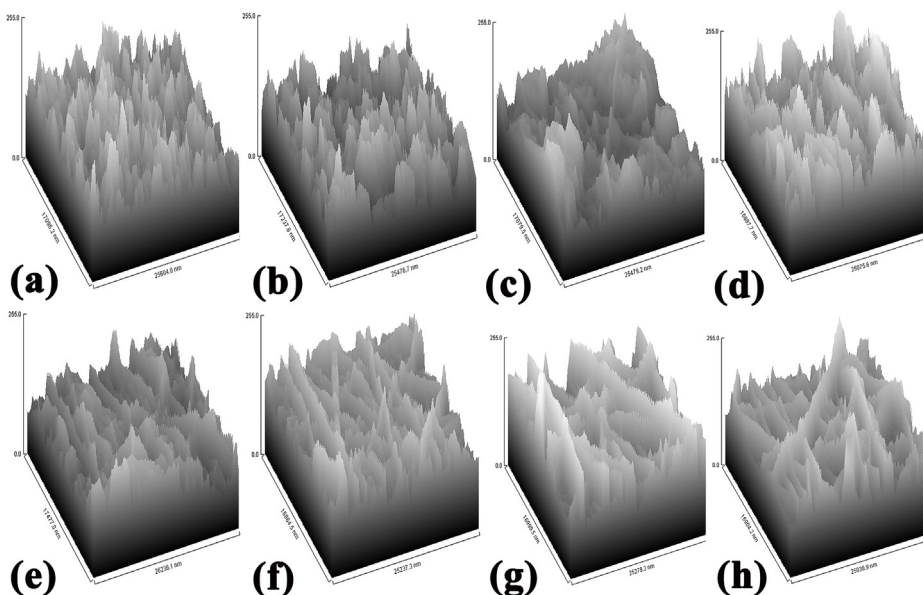


Fig. 7. Surface plot images of PC nanofibers obtained from 1:1 THF-DMF mixture (a) 7 w/v% (b) 9 w/v% (c) 11 w/v% (d) 13 w/v% (e) 15 w/v% (f) 17 w/v% (g) 19 w/v% and (h) 21 w/v%.

solutions.

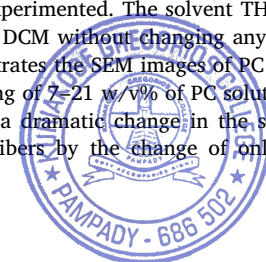
The gradual increase in the average fiber diameter with concentration and viscosity of various concentrations of PC is given in Fig. 8. At very low concentration and viscosity beaded fibers with very small average diameters were obtained. This is due to the insufficient viscosity and net charge in the solution to overcome the effect of surface tension. But with increase in solution concentration, viscosity increases and beadless fibers were obtained. A 17 w/v% PC solution in 1:1 THF-DMF mixture is most suitable for the preparation of uniform beadless fibers. Uniform beadless fibers with average diameter 524 nm were obtained at this concentration.

Another significant observation was the absence of electrospinning

phenomenon during the spinning of solutions of lower concentrations as reported earlier.

3.2. SEM image analysis of PC in 1:1 DCM-DMF mixture

In order to understand the effect of solvents on electrospinning, another solvent combination was experimented. The solvent THF was replaced by a more volatile solvent DCM without changing any other spinning parameters. Fig. 9 demonstrates the SEM images of PC nanofibers obtained by the electrospinning of 7–21 w/v% of PC solution in 1:1 DCM-DMF mixture. There was a dramatic change in the surface morphology of the prepared nanofibers by the change of only one



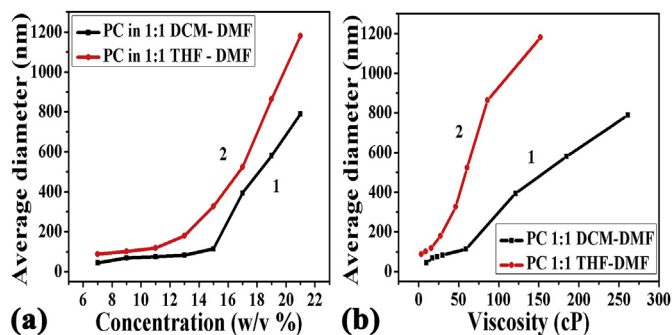


Fig. 8. The graphs of a) Concentration-average fiber diameter (1) PC in 1:1 DCM-DMF and (2) PC in 1:1 THF-DMF b) Viscosity-average diameter (1) PC in 1:1 DCM-DMF and (2) PC in 1:1 THF-DMF.

constituent of the solvent system. The average fiber diameter and bead density were significantly decreased. Beaded fibers were observed only for 7, 9, 11 and 13 w/v percentages of PC (viscosities 9.8, 17.3, 23.1 & 29.8 cP) solutions (Fig. 9(a–d)). The average diameters of fibers derived from 7, 9, 11 and 13 w/v percentages PC solutions were 44, 68, 75 and 83 nm respectively. Further increasing the concentration of the PC solution to 15 w/v% with viscosity 59.2 cP transparent and almost uniform fibers with average diameter 114 nm without any beads were obtained (Fig. 9(e)). At concentrations of 17, 19 and 21 w/v%, having solution viscosities of 121.1, 184.5, and 261.2 cP, beadless nanofibers were deposited on the target but with higher average diameters (Fig. 9(f–h)). A substantial change in fiber morphology can be observed at the concentration of 17 w/v% with an average fiber diameter of 394 nm. With further increase in concentration and viscosity of PC solution, average fiber diameter increased to a great extent and fiber uniformity decreased considerably.

Transparent fibers with average diameter of 581 nm were obtained for 19 w/v% polymer solution with viscosity 184.5 cP. Electrospinning of a 21 w/v% of PC solution with viscosity 261.2 cP was rather difficult due to the highly viscous nature of the solution. The viscosities of 17, 19 and 21 w/v percentages of PC solutions in 1:1 DCM-DMF mixture are very much higher than that of 1:1 THF-DMF mixture. The average fiber diameter obtained from 21 w/v% of PC in 1:1 DCM-DMF (788 nm) is comparatively less than that obtained from a 1:1 THF-DMF solution (1180 nm). These observations, showing the influence of solution concentration and viscosity on fiber morphology is in agreement with previous reports [55,56]. Change in surface morphology and subsequent decrease in bead density with increase in solution

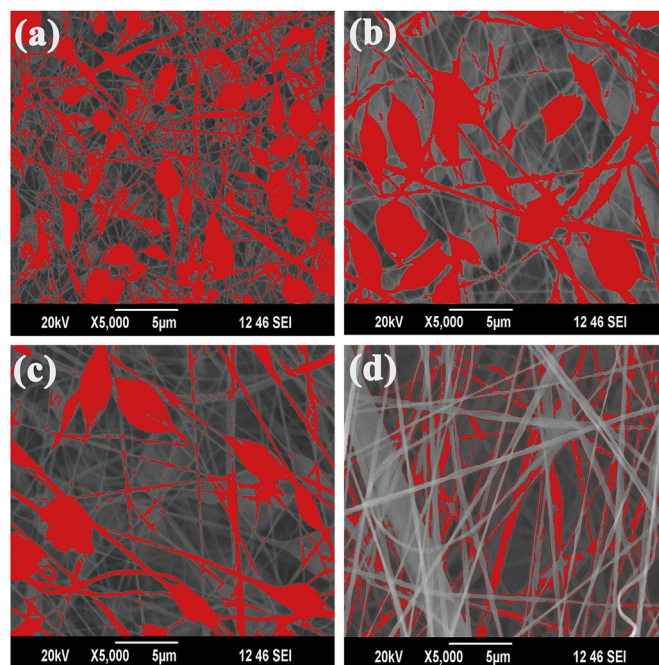


Fig. 10. Bead density images of PC fibers obtained from 1:1 DCM-DMF mixture (a) 7 w/v% (b) 9 w/v% (c) 11 w/v% and (d) 13 w/v%.

concentration and viscosity can be clearly seen. The variation of average diameter of electrospun PC fibers in 1:1 DCM-DMF mixture which is plotted as a function of both the concentration and the viscosity of the solutions is shown in Fig. 8. The average diameter of various concentrations of PC in 1:1 DCM-DMF mixture was found to be less than that of the fibers obtained from 1:1 THF-DMF mixture. Fig. 10 represent the bead density images obtained from the SEM images of various concentrations of PC in 1:1 DCM-DMF mixture. The bead density decreases with increase in solution concentration and viscosity. 7, 9, 11 and 13 w/v% of PC solutions produced fibers with bead densities of 38, 31, 20.2 and 3.3 respectively. The beads were totally absent in PC solutions with higher solution concentrations.

The decrease in bead density with increase in solution concentration and viscosity can be further confirmed from the concentration-bead density and viscosity-bead density graphs (Fig. 5(a) and (b)). The bead densities of the nanofibers obtained from 1:1 DCM-DMF mixture were very much less than the bead densities of the nanofibers obtained from

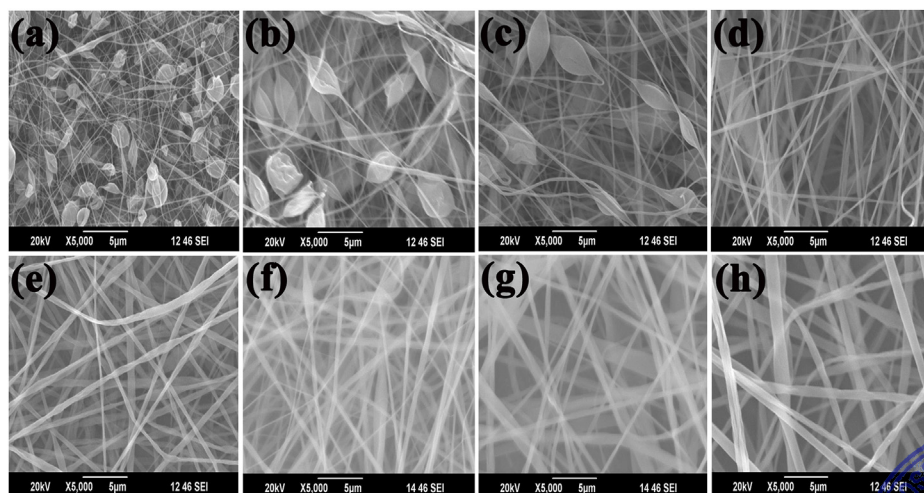


Fig. 9. SEM images of PC nanofibers obtained from 1:1 DCM-DMF mixture (a) 7 w/v% (b) 9 w/v% (c) 11 w/v% (d) 13 w/v% (e) 15 w/v% (f) 17 w/v% (g) 19 w/v% and (h) 21 w/v%.

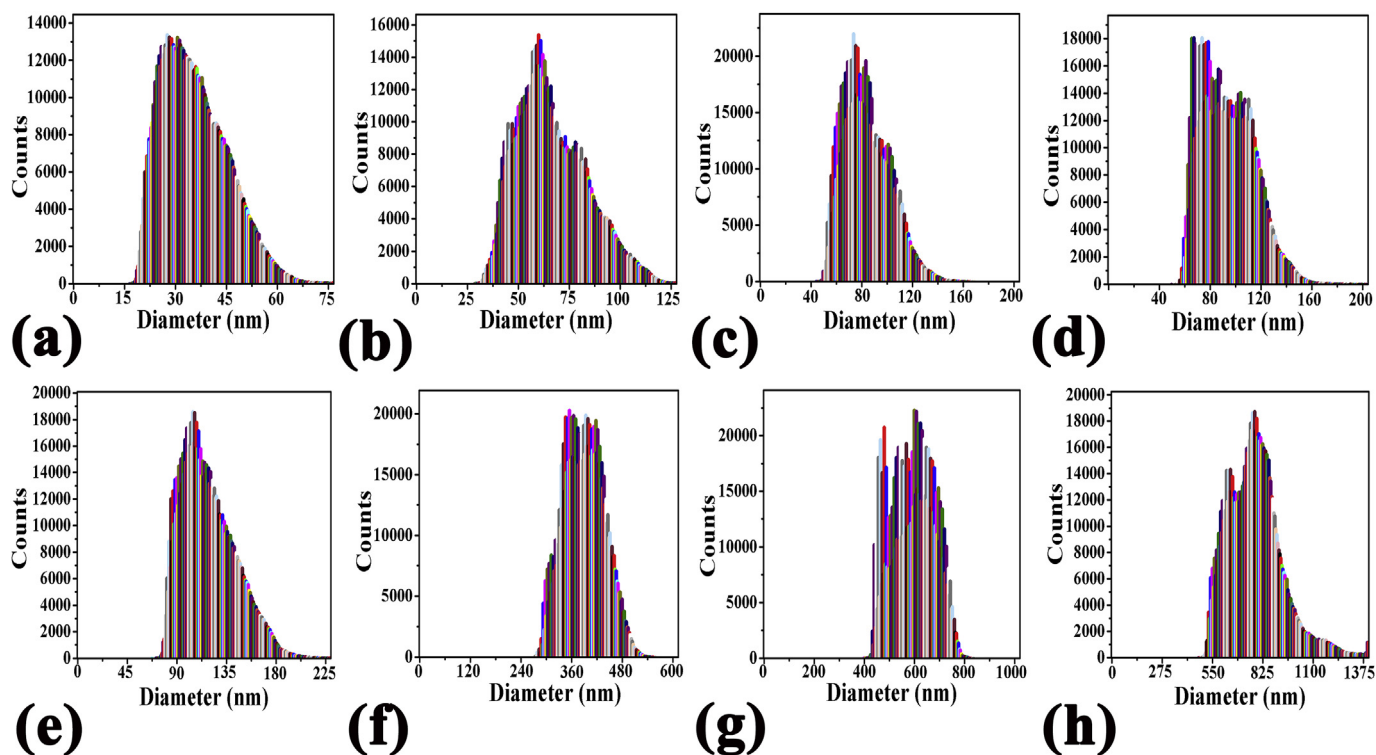


Fig. 11. Histograms of PC nanofibers obtained from 1:1 DCM-DMF mixture (a) 7 w/v% (b) 9 w/v% (c) 11 w/v% (d) 13 w/v% (e) 15 w/v% (f) 17 w/v% (g) 19 w/v% and (h) 21 w/v%.

1:1 THF-DMF mixture. A 15 w/v% of PC solution in 1:1 THF-DMF has a bead density of 5.45% while uniform beadless fibers were obtained for 1:1 DCM-DMF mixture at the same concentration. Fig. 11 shows the histograms of nanofibers of PC obtained from 1:1 DCM-DMF mixture. The histogram supports the fact that 15 w/v% of PC in 1:1 DCM-DMF is the most favorable proportion to obtain defect free, uniform and ultrafine fibers with the lowest average diameter among all the concentrations experimented (Fig. 11(e)). The non-uniform behavior of fibers at higher concentrations can be clearly identified from the histograms (Fig. 11(g) and (h)).

The surface morphology and uniformity of the nanofibers were also confirmed by preparing surface plot images from SEM micrographs as shown in Fig. 12. There was not much non-uniformity observed for the nanofibers in 1:1 DCM-DMF compared to 1:1 THF-DMF mixture.

From the information obtained from SEM analysis a 15 w/v% of PC in 1:1 DCM-DMF mixture has produced nanofibers with lowest average diameter of 114 nm with beadless uniform morphology. The solvent DCM in combination with DMF is highly efficient than the solvent THF in combination with DMF for the preparation of uniform beadless PC nanofibers with least average diameter.

3.3. Conductivity of PC solution and surface morphology of fibers

Solution conductivity depends on the nature of the solvent, the type of polymer dissolved and the entanglement of the polymer in the solution. Charge carrying capacity of almost all polymer solutions increases with increase in solution conductivity. This subsequently reduces the fiber diameter as there is an inverse relationship between radius of nanofiber jet and cube root of conductivity [57]. The variation of solution conductivity with concentration and viscosity of PC solutions in 1:1 THF-DMF and 1:1 DCM-DMF were studied. Comparison of solution conductivities of various concentrations and viscosities in the two solvent mixtures is given in Fig. 13.

The solution conductivity gradually decreases with increase in solution concentration and viscosity. Conductivity of PC solutions

decreased from 6.95 μS to 2.68 μS as the concentrations changed from 7 w/v% to 21 w/v % in 1:1 THF-DMF mixture. A gradual decrease in solution conductivity from 4.02 μS to 2.48 μS has been observed for the solution of PC in 1:1 mixture of DCM & DMF. Solution conductivities of various concentrations of PC in 1:1 THF-DMF mixture are higher than in 1:1 DCM-DMF mixture. The same trend can be observed for solution conductivity and viscosity. This may be due to higher polymer entanglement that reduces the mobility and subsequently the solution conductivity in 1:1 DCM-DMF mixture. At 21 w/v% solutions, conductivities are 2.68 and 2.48 μS for 1:1 THF-DMF and 1:1 DCM-DMF mixtures respectively. This shows that at very high concentration and viscosity the degree of polymer entanglement is almost same for the two solvent mixtures. Fig. 14 is the graphical representation of average diameter of the PC fibers with solution conductivity.

Nature of one of the solvent in the polymer solution has a great influence on solution conductivity. With change in solution conductivity change in surface morphology can be observed. Along with all other electrospinning parameters, solution conductivity definitely has an important role in fabricating polymer nanofibers with suitable morphology.

3.4. Characterization of PC nanofibers of 15 w/v% in 1:1 DCM-DMF mixture

Systematic control of various spinning parameters and the use of appropriate solvents and solution parameters are crucial for the successful preparation of ultrafine bead free fibers with lowest average diameter of 114 nm. Fig. 15 is the fiber mat obtained by the electrospinning of PC solution of 15 w/v% in 1:1 DCM-DMF mixture. As a highly useful material for wide variety of applications, the obtained fiber mat was characterized by various methods.

UV-Vis spectroscopic study shows good absorption properties for PC fibers with a maximum absorption of 275 nm in the ultraviolet region (Fig. 16(a)). A polymer with good UV absorption has wide variety of applications. Polycarbonate materials with ultraviolet absorption has

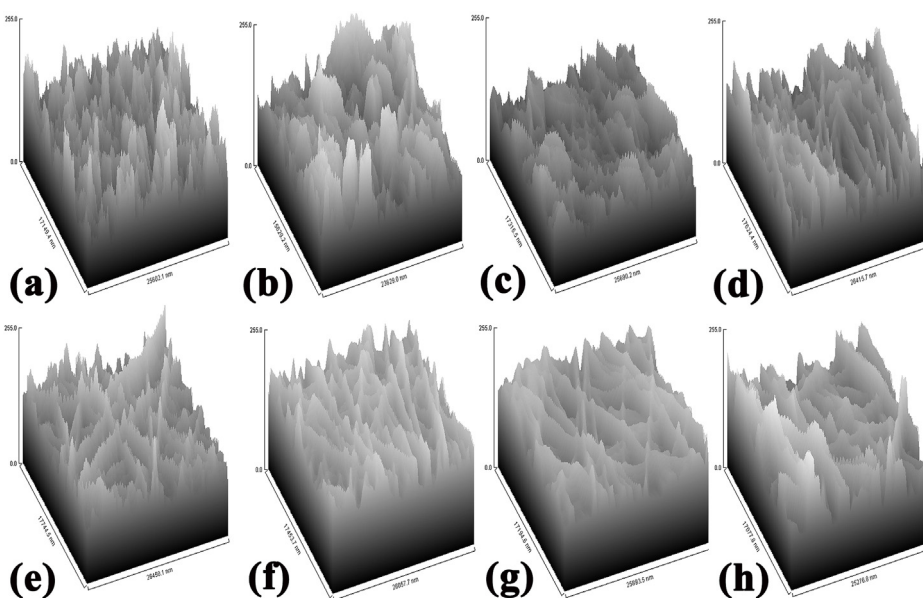


Fig. 12. Surface plot images of PC nanofibers obtained from 1:1 DCM-DMF mixture (a) 7 w/v% (b) 9 w/v% (c) 11 w/v% (d) 13 w/v% (e) 15 w/v% (f) 17 w/v% (g) 19 w/v% and (h) 21 w/v%.

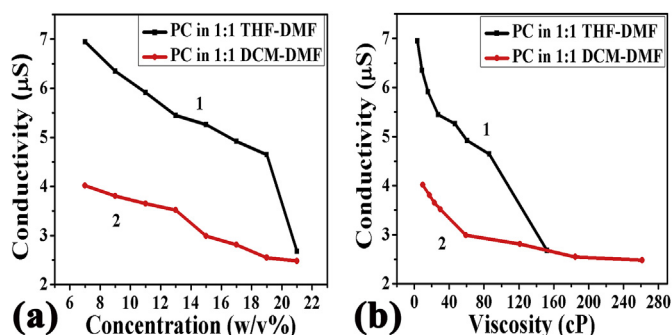


Fig. 13. a) Concentration-conductivity graph (1) PC in 1:1 THF-DMF and (2) PC in 1:1 DCM-DMF b) Viscosity-conductivity graph (1) PC in 1:1 THF-DMF and (2) PC in 1:1 DCM-DMF.

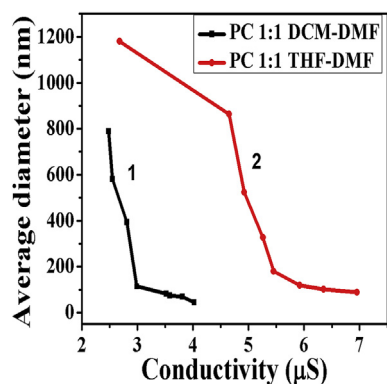


Fig. 14. Conductivity-average diameter graph of PC in (1) 1:1 DCM-DMF and (2) 1:1 THF-DMF.

been reported to be used in UV blocking materials like sun glasses, window glasses, roof shades, green houses, automobiles and in construction industry [58,59]. Diffraction pattern of PC fibers and PC pellets were compared and are shown in Fig. 16(b). PC pellet has characteristic amorphous peak but a change in the diffraction pattern of PC nanofibers clearly reveals its semicrystalline nature.

The characteristics vibrational modes of all the functional groups



Fig. 15. PC nanofiber mat from 15 w/v% solution in 1:1 DCM-DMF mixture.

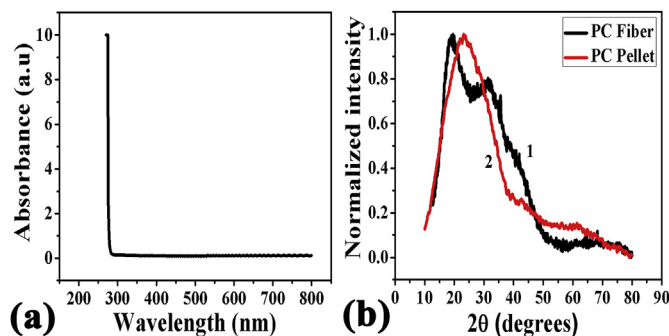


Fig. 16. 15 w/v% PC in 1:1 DCM-DMF mixture a) UV-Visible spectrum b) XRD pattern of (1) PC fiber and (2) PC pellet.

can be accurately validated from FT-IR spectral studies. The FT-IR spectra of PC nanofibers and the corresponding vibrational peak positions are given in Fig. 17(a). The characteristics vibrational peak at 659.75 cm^{-1} represents -C=C (aromatic) in-plane bending mode of vibration. A -CH (aromatic) out of plane bending vibrational peak can be observed at 827.63 cm^{-1} . The presence of carbonyl group in the polymer is confirmed by the presence of a -C=O asymmetric stretching vibrational peak at 1213.46 cm^{-1} . The peak at 1499.33 cm^{-1}

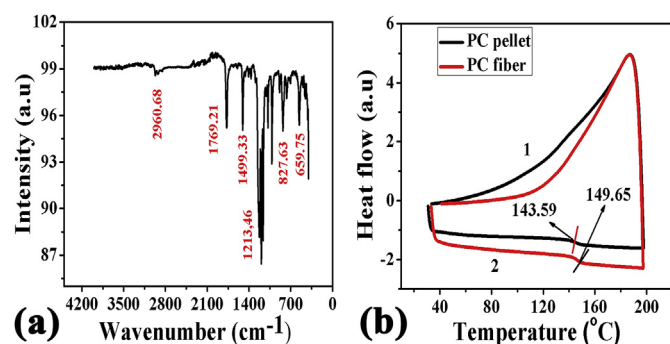


Fig. 17. 15 w/v% PC in 1:1 DCM-DMF mixture a) FT-IR spectrum b) DSC pattern of (1) PC pellet and (2) PC fiber.

Table 5

Tensile studies of 15 w/v% of PC in 1:1 DCM-DMF mixture.

Solvent system	Diameter (nm)	Ultimate strength (MPa)	Elongation at break (%)
1:1 DCM-DMF	114	0.7745 ± 0.14	63.2066 ± 12

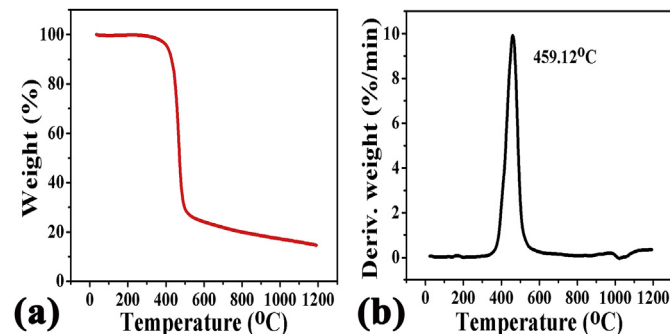


Fig. 18. (a) TGA and (b) dTG curves of PC nanofibers of 15 w/v% PC in 1:1 DCM-DMF mixture.

corresponds to $-\text{CH}$ (aromatic) in-plane bending vibration. The carbonyl symmetric stretching vibration can be observed at 1769.21 cm^{-1} . The $-\text{CH}$ symmetrical stretching vibration peak at 2960.68 cm^{-1} on the other hand confirms the presence of methyl groups in the PC chain.

Glass transition temperature (T_g) is an important parameter of a polymer to know the temperature at which a phase transition occurs. The DSC curves of PC pellet and that of the PC nanofibers obtained by the electrospinning of 15 w/v% of PC solution in 1:1 DCM-DMF mixture is given in Fig. 17(b). The T_g values of PC pellets and PC fibers are 143.59°C and 149.65°C respectively. Conversion of PC pellets into defect free ultrafine fibers has a great influence on T_g as it increases compared to its bulk polymer. Polymer entanglement during electrospinning that reduces mobility may be one of the reason for increase in T_g of the nanofibers.

The produced nanofibers were also characterized using thermogravimetric and tensile strength analysis. The fibers were found to have a tensile strength of $0.7745 \pm 0.14\text{ MPa}$ and elongation at break of $63.2066 \pm 12\%$ (Table 5).

The produced fibers were also found to have a thermal stability of up to 305.50°C (Fig. 18(a)). Absence of initial weight loss indicates the fiber sample was free of moisture and other degradation.

A 5% degradation was observed in the range 305.50°C – 403.77°C . This immediately follows a sharp degradation from 407°C to 499°C which corresponds to a main degradation zone with 71.81% reduction. 14.30% residue was obtained at a temperature of 1200°C . PC at lower degradation stage releases alkyl substituted phenols and with further increase in temperature related products such as CO_2 , H_2O , CH_4 and CO

are formed [60]. The degradation happens in a single stage with a maximum degradation temperature of 459.12°C that can be observed from the corresponding dTG curve (Fig. 18(b)).

4. Conclusions

In nutshell, this new approach of electrospinning process to prepare beadless, uniform PC nanofibers is simple, efficient and cost effective. The characteristics like ultraviolet absorption properties by maintaining an optimum average diameter of 114 nm will be an attractive feature for leveraging this process. The preparation of different concentrations of PC was accomplished by two different solvent mixtures; by keeping the process under an optimized spinning condition. A 15 w/v % of PC in 1:1 DCM-DMF mixture was found to be the most suitable for the production of defect free fibers with lowest average diameter. Comparison of viscosities and conductivities of the PC solutions in these two different solvent mixtures were helpful to understand their impact on the production of nanofibers. Despite of being toxic in nature, THF is the most commonly used solvent for the electrospinning process of various polymers. An alternative is DCM, which is less toxic and highly volatile. As a solvent, DCM is known for its capability to dissolve polymers that attributes to a highly controllable electrospinning process. When it comes to the capability of dissolving polymers, electrospinning of PC in solvents like THF, DMF and CHCl_3 are not considered as an appropriate method. Moreover high average diameter of the as-spun fibers also make it less attractive. The surface morphology of the products of this electrospinning method shown distinguishable behavior in their characteristics such as solution concentration, viscosity, and conductivity. In addition to its semi-crystalline nature, it has sharp absorption capability in the ultraviolet region along with elevated glass transition temperature and thermal stability. All these features together make the ‘beadless ultrafine fibers with lowest average diameter of 114 nm’ an appropriate material for many modern applications like air and water purification, tissue scaffolding, sensors, ultraviolet blocking and removal of hazardous metals.

Conflicts of interest

The authors do not have any conflict of interest to declare.

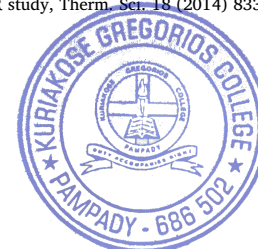
Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.polymertesting.2019.106103>.

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Preparation and characterization of luminescent polycarbonate nanofibers embedded with surface capped CdS nanoparticles

Cite as: AIP Conference Proceedings **2162**, 020013 (2019); <https://doi.org/10.1063/1.5130223>
Published Online: 29 October 2019

Thomas Baby, and E. Tomlal Jose



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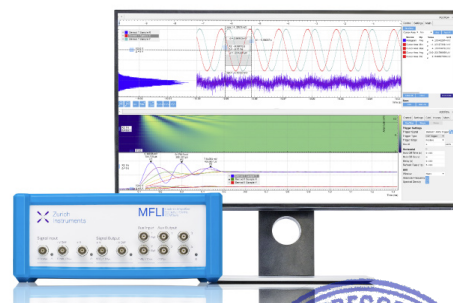
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Preparation and Characterization of Luminescent Polycarbonate Nanofibers Embedded with Surface Capped CdS Nanoparticles

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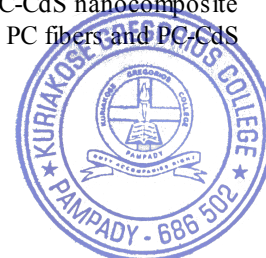
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Abstract. As an important engineering material with tremendous utilities, polycarbonate (PC) and its composites are contributing a major role among highly useful materials. Preparing ultrafine fibers with defect free surface morphology is a challenge in the field of nanotechnology. In the present work ultrafine bead free PC fibers with average diameter very close to 100 nm were prepared by optimizing various spinning parameters during electrospinning fiber fabricating technology. At the same spinning conditions PC nanocomposite fibers were prepared by incorporating surface modified cadmium sulphide (CdS) nanoparticles with prominent optical properties. The prepared PC-CdS nanocomposite fibers have excellent absorption and emission properties and also exhibit semi-crystalline nature. By increasing the nanoparticle concentration there was remarkable improvement in the thermal stability of the PC nanocomposite fibers.

INTRODUCTION

Modern field of nanotechnology is in search of materials that can improve the quality of human life through the development of various fields including medicine, tissue engineering, electronics, automobile, energy related materials and so on [1]. Poly (Bis phenol A carbonate) commonly called polycarbonate (PC) is an emerging material with excellent mechanical, thermal, heat resistance and optical properties [2]. Polymers in the form of thin films and fibers are attractive materials in the area of research due to their large surface area and small pore size. There are different methods for the preparation of polymer nanofibers including drawing, self-assembly, phase separation, template synthesis and electrospinning [3]. Electrospinning is the most accepted method for the mass production of long and continuous fibers by the application of high electric potential [4]. Polymer nanocomposites prepared by incorporating various nanofillers were widely studied due to their amazing properties [5, 6]. Semiconductor nanoparticles especially II-IV chalcogenide like cadmium sulphide (CdS) has immense applications that were reported by many researchers [7]. Agglomeration of nanoparticles during preparation was a hurdle for their smooth dispersion. Capping assisted fabrication of nanoparticles has helped to resolve such difficulties which facilitated proper dispersion and overall manipulation of tunable properties [8].

In the present contribution CdS nanoparticles were synthesized by a simple low temperature method by surface modification using oleic acid (OA) as a capping agent. PC fibers with very small diameters were prepared by adjusting various electrospinning parameters. Under the same electrospinning parameters PC-CdS nanocomposite fibers were prepared by dispersing CdS nanoparticles in PC solution. The CdS nanoparticles, PC fibers and PC-CdS



nanocomposites were elaborately studied by various characterization methods like Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), UV-Visible spectroscopy, Photoluminescence (PL) spectroscopy, X-Ray diffraction (XRD) studies and Thermogravimetric analysis (TGA).

EXPERIMENTAL

PC pellets were procured from Sigma-Aldrich, USA. Cadmium nitrate tetrahydrate ($\text{Cd}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$), Oleic acid (OA), Sodium sulphide (Na_2S), Tetrahydro furan (THF) and N, N dimethyl formamide (DMF) were purchased from Merck India Ltd

Preparation of OA capped CdS nanoparticles

3.72 g of $\text{Cd}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$ was dissolved in 30 ml ethanol. 0.7 g OA was added and stirred for 15 minutes. To this solution 0.9 g Na_2S dissolved in ethanol was added slowly and stirred for further five hours. The precipitated yellow crystals were filtered, washed and dried. This was annealed at 200°C for 2 h.

Preparation PC nanofibers embedded with CdS nanoparticles

Three separate solutions of 16 w/v% of PC in 1:1 THF and DMF were prepared. 1, 2 and 4 w/w percentages of CdS nanoparticles were dispersed in the prepared PC solutions by proper stirring and further 30 minutes sonication. The solutions were kept for 24 h continuous stirring. This was then taken in a 5 mL syringe and electrospun under optimized conditions at a flow rate of 0.5 mL/h, 20 kV applied voltage and a distance of 15 cm between the tip of the needle and collection plate. The fibers were collected on an aluminium foil fixed over the metal collecting plate.

RESULTS AND DISCUSSION

Characterization of OA capped CdS nanoparticles

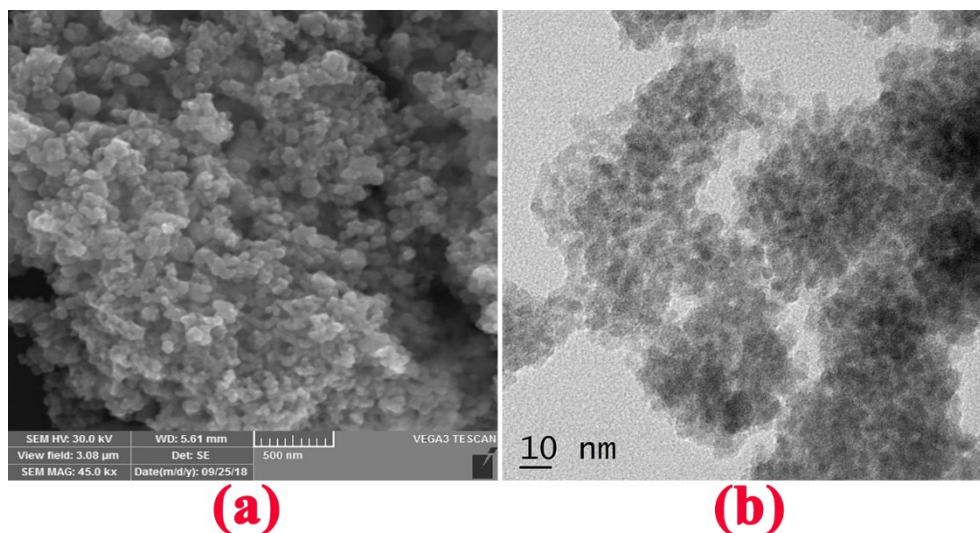


FIGURE 1. (a) SEM and (b) TEM micrographs of OA capped CdS nanoparticles.

Less agglomerated and highly dispersive CdS nanoparticles with spherical surface morphology can be observed from SEM micrograph. The reduced agglomeration is also evident from the TEM image. The surface capping method adopted for the preparation of CdS nanoparticles was found to be highly suitable to reduce aggregation of nanoparticles.



The UV-Visible spectrum (Fig 2(a)) shows absorption both in ultraviolet and visible region with an excitonic peak at 446 nm. Excitation at 446 nm shows strong emission property with a green emission sharp at 533 nm (Fig 2(b)). Diffraction studies established a cubic crystal lattice with average particle size 14 nm as shown in Fig 2(c). TGA analysis confirmed the presence of OA as a protective layer that removed by a first phase decomposition and a maximum decomposition temperature of 1006.39°C for the prepared nanoparticles (Fig 2(d)). The OA capped CdS nanoparticles exhibits characteristics optical and thermal properties due to quantum confinement effect [9].

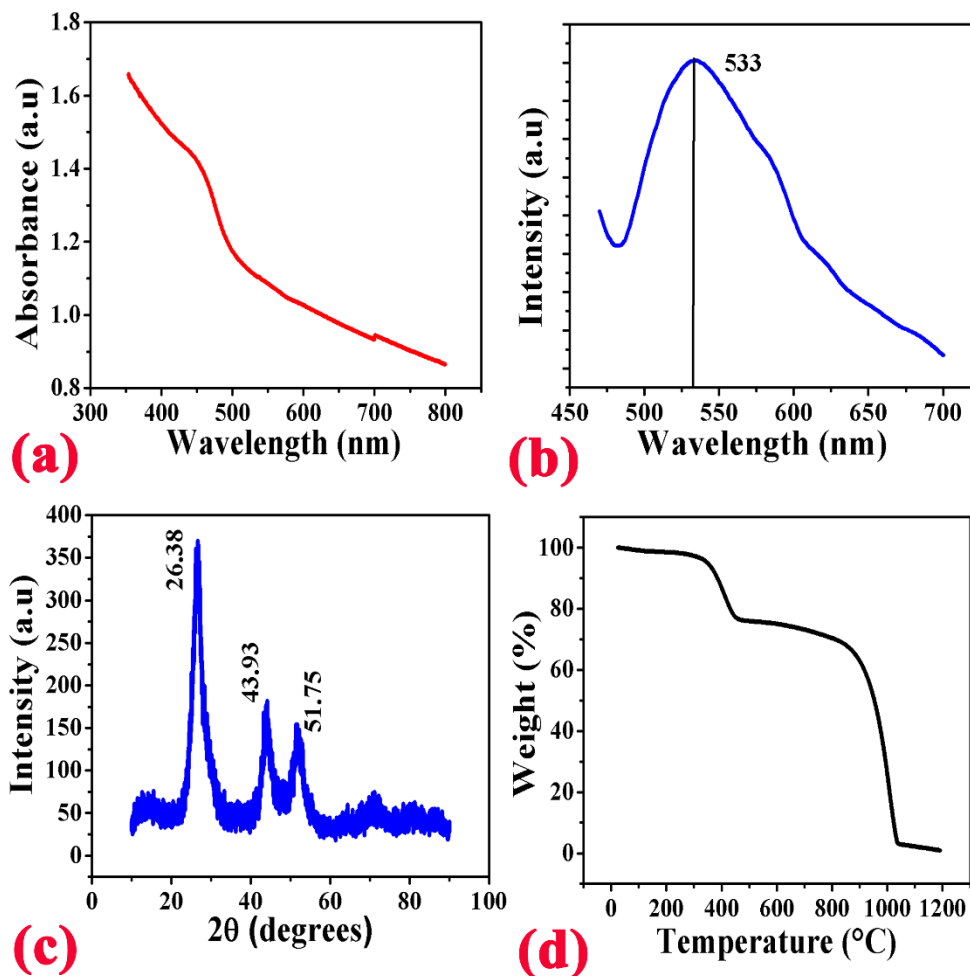


FIGURE 2. (a) UV-Visible spectrum (b) PL spectrum (c) XRD pattern and (d) TGA curve of OA capped CdS nanoparticles.

Analysis of PC-CdS nanofibers

Figure 3 depict the SEM micrographs of plane PC and PC-CdS nanocomposite fibers. The prepared nanofibers have beadless ultrafine morphology with almost uniform fiber diameter. Average diameter of 114 nm was obtained for plane PC fibers (Fig 3(a)). With increase in CdS loading the average fiber diameter increases and becomes 176 nm for 4 w/w% of CdS in PC matrix (Fig 3(d)). The average diameters of PC fibers with 1 and 2 w/w% of CdS are 135 and 156 nm respectively (Fig 3(b) and (c)). This was probably due to the change in viscosity and surface tension of the polymer solution occurred by varying the amount of nanofiller. These factors influenced the fiber entanglement and overall morphology of the electro-spun fibers [10].



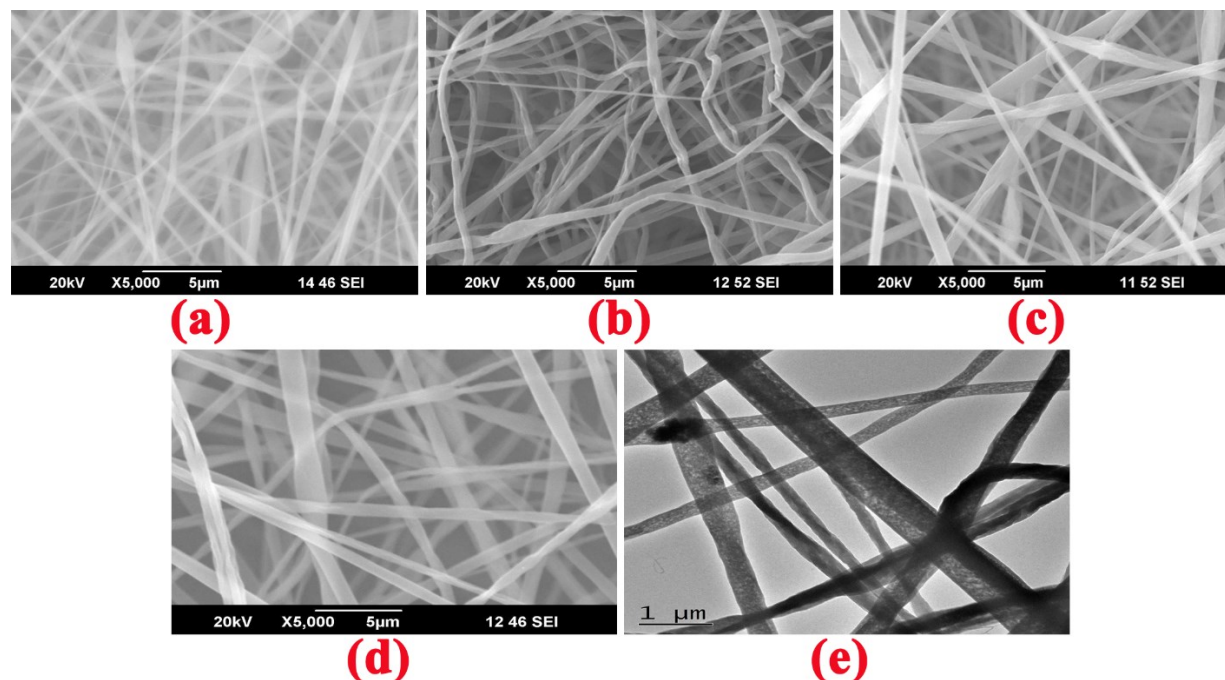


FIGURE 3. Electro-spun fibers of (a) PC 16 w/v% (b) PC-CdS 1 w/w% (c) PC-CdS 2 w/w% (d) PC-CdS 4 w/w% and (e) TEM image of PC-CdS nanocomposite fibers.

The TEM image demonstrates uniform distribution of CdS nanoparticles all over the PC fibers as shown in Fig 3(e). The embedded nanoparticles have significant role in tuning the optical properties of the nanocomposite fibers. The UV-Vis spectra of pure PC fibers and that of the PC-CdS nanocomposite fibers are given in Fig 4(a). There was a dramatic change in the absorption properties of PC fibers after varying the amount of CdS nanoparticles. The nanocomposite fibers exhibit absorption in ultraviolet and visible region and the intensity of absorption increased by filler loading. This is an outcome of excellent host-guest interaction between the PC matrix and CdS nanoparticles. The photoluminescence (PL) spectra of pure PC fibers and the nanocomposites are provided in Fig 4(b). PL spectral studies of pure PC fibers at an excitation wavelength of 300 nm shows characteristics emission at 374 nm in the ultraviolet region and a small emission peak at 735 nm in the near infrared region. Quenching of emission at the UV and near IR region and a new emission in the visible region observed for PC-CdS nanocomposite fibers are highly remarkable. This was found to be prominent by increasing the amount of CdS nanoparticles. The observed luminescence phenomenon was an outcome of probable excitonic transition from the bottom of the conduction band to the top of the valence band. X-ray diffraction (XRD) patterns show amorphous halo embedded with semi-crystalline peaks as shown in Fig 4(c). PC in bulk form shows perfectly amorphous character with an amorphous halo in the XRD pattern. But PC fabricated in the form of nanofibers has some semi-crystalline character. The semi-crystalline nature found to be enhanced by increasing the amount of CdS nanoparticles in the polymer matrix. The diffraction angles at 19.10° and 31.61° for pure PC fiber show slight shift in the peak positions with increase in the nanoparticle concentration. 17.92° and 26.91° for 1 w/w% CdS, 17.54° and 27.33° for 2 w/w% CdS and 17.92° and 31.23° for 4 w/w% CdS are the diffraction angles observe for various nanocomposite fibers. This is due to the efficient interaction between the polymer matrix and the crystalline nanoparticle guest material. Due to the uniform distribution of crystalline nanoparticles in the polymer the semicrystalline nature of the nanofibers get increased.



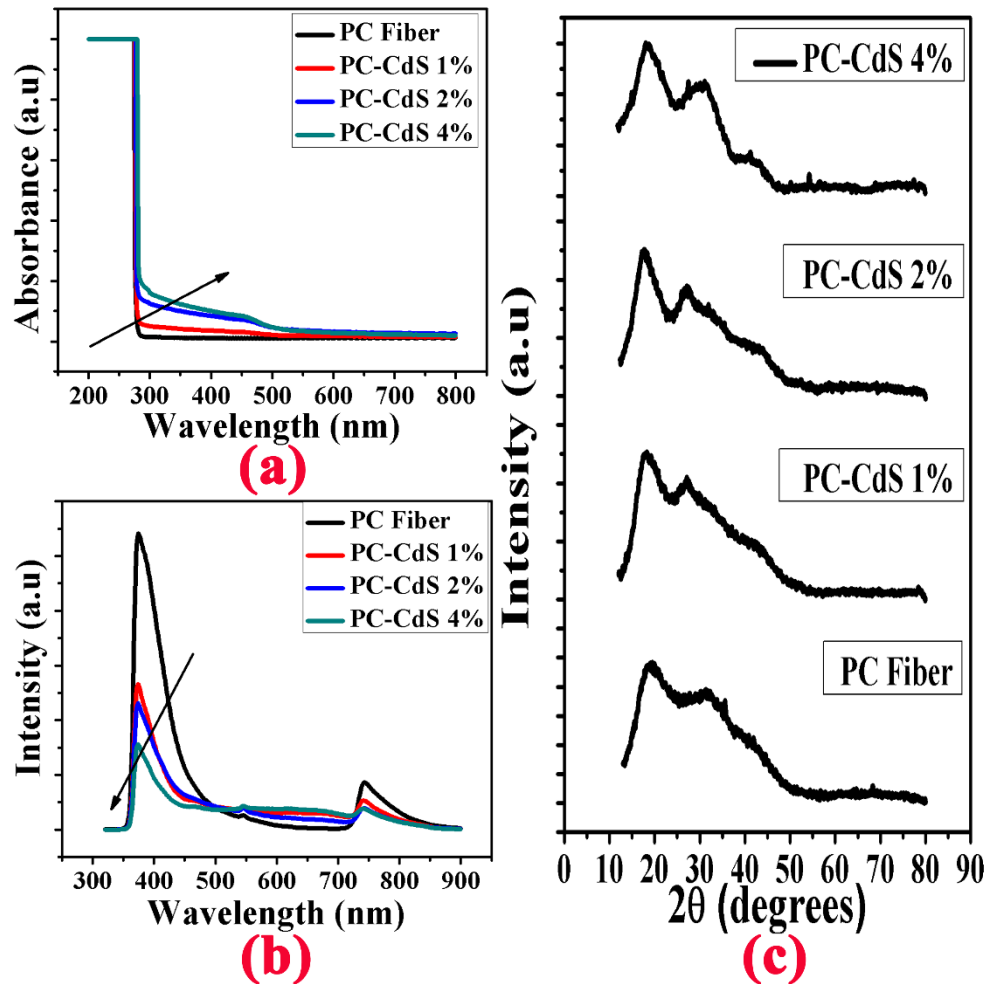


FIGURE 4. (a) UV-Vis spectra (b) PL spectra and (c) XRD patterns of PC-CdS nanocomposite fibers.

The TGA and the corresponding dTG curves of pure PC fibers and that of the nanocomposite fibers are shown in Fig 5. A gradual increase in thermal stability of the nanocomposites with the addition of CdS can be observed from the TGA curves (Fig 5(a)). The enhanced thermal stability was further confirmed by analyzing the dTG curves (Fig 5(b)). Table 1 shows the maximum degradation temperature (T_M^o) of pure PC and PC-CdS nanocomposite fibers measured from the dTG curves. Uniform distribution of nanofillers in the polymer matrix has created sufficient chain entanglement which may be the reason for the enhanced stability of the PC-CdS nanofibers.

TABLE 1. Maximum degradation temperature values of PC fiber and PC-CdS nanocomposite fibers.

Sample	T_M^o ($^{\circ}$ C)
PC Fiber	467.79
PC-CdS 1%	478.85
PC-CdS 2%	483.25
PC-CdS 4%	501.11



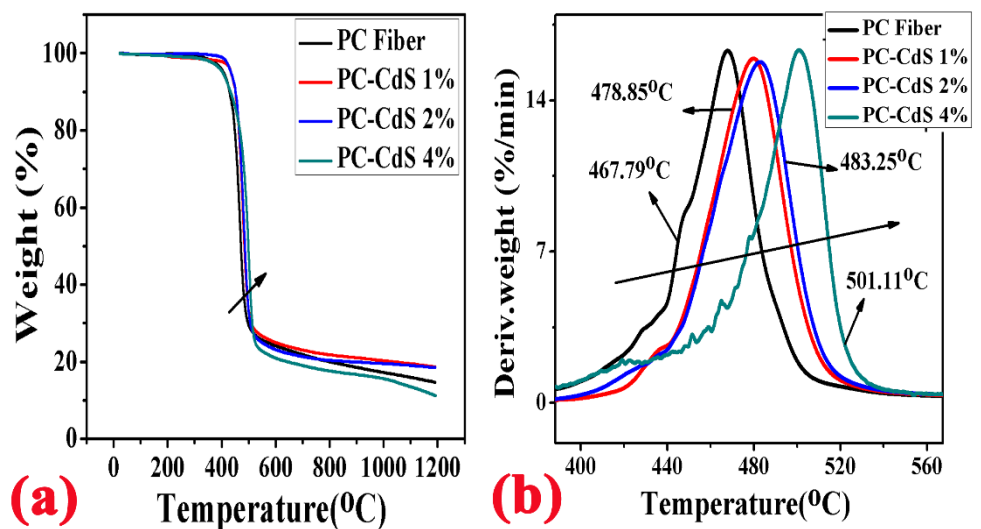


FIGURE 5. (a) TGA and (b) dTG curves of PC-CdS nanocomposite fibers.

CONCLUSION

OA capped CdS nanoparticles were effectively dispersed in PC and generated bead free nanocomposite fibers with attractive properties for wide variety of capabilities including opto-electronics applications. Increase in the ultraviolet absorption, quenching of emissions in ultraviolet and near infra-red regions and the appearance of a new visible light emission are indications of superior luminescence and excellent guest-host interaction between the polymer and the nanoparticles. A clear demonstration of increase in the semi crystalline nature of the composites with increase in the nanoparticle concentration can be observed from diffraction studies. The enhanced thermal stability of the composite covers PC-CdS nanocomposites fibers in the list of stable nanomaterials.

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Strategy for Banks in India in the Era of Economic Slowdown: Need for Thrust on Retail Banking with a Focus on Housing Finance

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Received: 14 April 2020 Revised and Accepted: 8 August 2020

Abstract

It is widely recognized that India is passing through an era of acute economic slowdown and there is an imminent need for kick-starting the economy by way of suitable revival measures. Indian banking sector is facing unprecedented challenges, like, mounting NPAs, diminishing profitability, eroding capital and so on. At this critical juncture, what could be the broad strategy for the industry that can get rid of most of these chronic issues and at the same time ensure sustained growth and profitability without compromising on asset quality? What could be the strategy to create more employment and also to revive the key sectors of the economy? This paper analyses the need for a strategy of 'Retail banking focus with a housing finance thrust, along with proper ICT integration', and the capability of this strategy to diversify risks, maintain asset quality, reduce bad debts, create employment avenues, lure the new generation customers, and above all kick-start the recession-hit sectors of the economy because of the vast linkages of housing industry. Retail banking is the only feasible strategy for public sector banks (PSBs) in the current era of PSB consolidation. This strategy suits well with the national goal of 'Housing for All by 2022'. The role of banks in meeting this key goal by fulfilling the housing finance needs of the masses will be more vital in the future, since the market share of housing finance companies (HFCs) that has already been falling will start falling faster with the RBI's mandate to link loan rates to some specific external benchmark from 01st Oct.2019. Government package for housing sector declared on 14th Sept.2019 will boost housing credit.

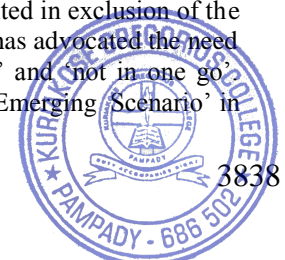
Keywords: ICT, Retail Credit, Housing finance, Risk diversification, External benchmark.

1. Introduction

As waves of 'knowledge revolution' are sweeping across the globe, worldwide there is a gradual but certain transformation into a knowledge society from the post-industrial society. A similar and inter-related trend is the fast advances in Information and Communication Technology (ICT) – an outcome of the 'electronic revolution'. Knowledge revolution and electronic revolution are bringing about radical changes in the way in which organizations are being managed, business operations are being performed and state governance is being done. Indian economy is no exception to the above global trend and so also is the case of banking and financial services industry (BFSI) in India. 'Digital India' is a national goal of the country and the fast pace at which ICT advances are embraced by the BFSI sector in India has resulted in rapid growth of the Financial Technologies ('Fin-Tech') entities in India. On the one hand, there is fast-paced ICT integration and also a boom in Fin-Tech units. On the other hand, Indian economy is facing an acute economic slump and this slowdown is reflected in all facets of the economy including the banking sector of the country. Whether the nature of economic slowdown is cyclical or structural or partly of both, there is certainly the need for well thought-out and meticulously designed policies that can mitigate the adverse effects of the slowdown. So, policies capable of attracting more private investment, those that can kick-start the recession-hit sectors and also create multiplier effects capable of reviving the vital sectors of the economy are inevitable for sustained economic growth. In this context, promotion of retail credit, particularly housing loans is very relevant because it can ensure higher credit off-take and also kick-start about 300 allied sectors.

2. Literature Review and Research Gap

Peer Smets (1999) [30], in his paper 'Housing Finance Trapped in a Dilemma of Perceptions: Affordability Criteria for the Urban Poor in India Questioned' in *Housing Studies* has argued that a definitional issue associated with formal housing finance and 'eligibility' for the same in terms of 'affordability criteria in one go' has resulted in exclusion of the vast majority of the urban poor from availing finance from formal sources of finance. The author has advocated the need for 'incremental housing' and also the need to assess the 'affordability in a phased in manner' and 'not in one go'. Manoj P K (2003) [13] in his research paper, 'Retail Banking: Strategies for Success in the Emerging Scenario' in

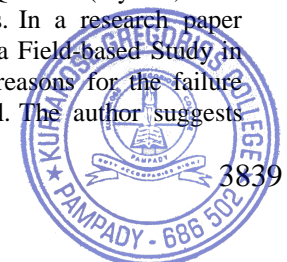


IBA Bulletin has suggested strategies for the sustained growth of the retail advances of banks which primarily include housing loans, since such advances provide a safer means to enhance business and to kick-start the recession-hit Indian economy of the early 2000s. Linkage effects of housing (of forward and backward types, both) with numerous other industries, and the positive effect of such linkages for bringing about faster economic growth have been pointed out in the paper. Manoj P K (2004) [14] in his another research paper, 'Dynamics of Housing Finance in India' in *Bank Quest* has pointed out the growing appetite of commercial banks (CBs) towards housing loans, the declining market share of housing finance companies (HFCs), and such allied issues. A few macro level suggestions for enabling the sustained and balanced growth of housing finance are given. The need for encouraging the secondary mortgage market (such as RMBS), alternative means of providing housing finance such as Housing Micro Finance (HMF) etc. have been given. In a Working Paper 19 titled, *Housing Microfinance: Designing a Product for the Rural Poor*, released by Institute for Finance Management and Research (IFMR) (2007)[7], has noted the utmost significance of encouraging Housing Micro Finance (HMF), alternative mode of providing home loans to the poor, for the purpose of addressing India's chronic housing problem which in turn is mainly the housing problem of the poor and the marginalized in India, like the Low Income Group (LIG) and Economically Weaker Sections (EWS). Only models like HMF could cater to such deprived sections that are not served by the formal sector agencies. So, models like HMF are required to solve India's 'real housing problem'. The report seeks to design the suitable HMF model for the Indian poor.

Manoj P K (2008) [15] in his paper, 'Learning from Cross-country Experiences in Housing Finance: A Microfinance Approach' in *Journal of Global Economy* has suggested suitable macro level strategies for promotion of housing micro finance (HMF) in the Indian scenario by appropriately replicating the successful and time-tested models like HMF or other similar alternative housing finance models prevalent elsewhere in the world. A research paper on HMF by Manoj P K (2010) [21], "Prospects and Problems of Housing Microfinance in India: Evidence from 'Bhavanashree' Project in Kerala State" in *European Journal of Economics, Finance and Administrative Sciences* has studied in detail the utmost importance of HMF for balanced and equitable housing development in India, and hence rapid economic development of the country. Strategies for promotion of HMF in India have been suggested, along with specific and category-wise strategies for the HMF based in Kerala and sponsored by the state government namely 'Bhavanashree'. Manoj P K (2010) [18] in his paper, 'Benchmarking Housing Finance Companies in India: Strategies for Enhanced Operational Efficiency and Competitiveness' in *European Journal of Economics, Finance and Administrative Sciences* has made a detailed analysis of the relative competitive position of the leading housing finance companies (HFCs) in India and has suggested strategies for the enhanced operational efficiency and competitiveness of HFCs.

The management consultancy organization, KPMG (2010) [11], in its Industry Report (Advisory), '*Affordable Housing – A key growth driver in the real estate sector?*' has sought to discuss the immense growth prospects of real estate players in the affordable housing market in India, given the huge demand and grossly under-penetrated market, very favourable Governmental policies etc. The demand and supply constraints, the relevance of PPP in the real estate sector etc. have also been dealt in detail. In a research paper by Manoj P K, (2010) [19] 'Determinants of Successful Financial Performance of Housing Finance Companies in India and Strategies for Competitiveness: a Multivariate Discriminant Analysis' in *Middle Eastern Finance and Economics*, has attempted to find the determinants of superior financial performance of HFCs. Using the tool Multivariate Discriminant Analysis (MDA), Discriminant Function having five distinct parameters (selected from the total 21 parameters used for MDA) which significantly influence the financial performance of HFCs has been derived. Yet another paper by Manoj P K (2010) [17], 'Financial Soundness Housing Finance Companies in India and Determinants of Profitability: A 'CAMEL' Approach along with ROE Decomposition Analysis' has employed the methodology of 'CAMEL' ranking along with ROE decomposition analysis to identify the determinants of profitability of HFCs. A research paper by Manoj P K (2011) [22], 'Determinants of Profitability of Housing Finance Companies in India and Strategies for Competitiveness: a Multiple Partial Correlation Approach' in *International Journal of Business Intelligence and Management* has suggested competitive strategies for various groups of HFCs with the help of the basic parameters that significantly influence the respective groups of HFCs.

A joint research paper by Hrushikesh Mallick & Mantu Kumar Mahalik (2015)[5] 'Factors determining regional housing prices: evidence from major cities in India', in *Journal of Property Research* has sought to identify the factors determining the housing prices with respect to 15 major cities in India using data relating to 16 Quarters (4 years, 2010 to 2013). It has been noted that fundamental factors are more significant than speculative factors. In a research paper by Manoj P K (2015) [25], "Socio-Economic Impact of Housing Microfinance: Findings of a Field-based Study in Kerala, India", published in *International Research Journal of Finance and Economics*, the reasons for the failure of 'Bhavanashree' – the HMF initiative of the Government of Kerala have been studied in detail. The author suggests



strategies for effective implementation of HMF projects based on the “learning from the failure of ‘Bhavanashree’ project” in Kerala. The research report by the agency IFMR (2015) [8] entitled *Affordable Housing Finance Sector: Overview* makes a detailed analysis of the need, relevance and significance of affordable housing in India in the context when the national goal of ‘Affordable Housing for All by 2022’ is implemented by the Government of India. The crucial role that HFCs have to play in this context is specially noted in the IFMR report. The fact that there is a gradual re-emergence of HFCs since 2013, thus overtaking the CBs in growth rate and significantly improving their market share has been specifically pointed out. In a paper by Manoj P K (2015) [23], “Deterrents to the Housing Microfinance: Evidence from a Study of the Bankers to ‘Bhavanashree’ in Kerala, India”, in *International Research Journal of Finance and Economics*, the major problems associated by the bankers in financing ‘Bhavanashree’, the HMF initiative of the Government of Kerala, has been dealt in detail. Various issues like the unclear land tenure, fragile institutional framework of the HMF and its parent (mentor) ‘Kudumbashree’ etc. have been studied in detail. Suggestions have been made to the Government based on the findings of the study, for the purpose of enabling more meaningfully implement HMF initiatives in the future, ‘Bhavanashree’ initiative being more or less a failure.

In a research article by Manoj P K (2015) [24], “Housing Microfinance: A Study on Quality, Cost and Default Rate with Respect to ‘Bhavanashree’ in Kerala”, in *International Research Journal of Finance and Economics*, a detailed and critical study of the asset quality, administrative (transaction) costs, and default rates in respect of the HMF initiative of the Government of Kerala ie. ‘Bhavanashree’ has been made. Suggestions are made for more effective implementation of HMF projects by the Government. Another paper by Manoj P K (2016) [26], “Real Estate Investment Trusts (REITs) for Faster Housing Development in India: An Analysis in the Context of the New Regulatory Policies of SEBI” has examined in detail the vital significance of REITs in an emerging economy like India for promoting its real estate and allied sectors and hence the economy as a whole. BCG (2018) [2] in its *Digital Lending* has highlighted the immense opportunity for digital lending in India. Accordingly, it is a USD 1 Trillion opportunity over the next 5 years and the stakeholders can utilize the same.

In view of the foregoing discussions, it is noted that though there are many studies on housing finance, studies that focus on the special role of banks in combating the evils of economic slump are scarce. This study is one in the above direction and it is a critical relook into the studies by Manoj P. K. (2003) [13] on retail banking and Manoj P. K. (2004) [14] on housing finance.

3. Relevance and Significance of the Study

It is widely recognized that Indian economy is passing through an economic slump and the Government of India itself has acknowledged the fact stating that the GDP growth during the first Quarter of FY 2019-20 (i.e. Q1 of 2019-20) is just 5 percent, much lower than the earlier estimates of over 6 percent. The vast linkage effects of housing investments which in turn results in investments in other allied sectors and its ability to generate employment are well recognized. Given the fast pace of ICT adoption by the banking industry and the discerning nature of modern customers who prefer only modern delivery channels facilitated by ICT integration, the need for ICT integration in retail banking parlance need not be overemphasized. The fast growth of the Fin-Tech industry that poses a challenge even to the traditional players like banks gives another dimension to the need for embracing ICT in banking services, particularly in retail banking. The mounting NPA issues primarily arising from large corporate or industrial loans can be offset by extending retail credit, as retail loans like housing finance have low level of bad debts. Besides, retail loans can diversify the concentration risks associated with banking, these being extended to many borrowers who are widely scattered. In this context, it is relevant to critically study the need for promoting retail banking with a focus on housing loans, with due ICT-integration too.

4. Research Questions, Objectives of the Study and Methodology

The research questions are: What should be the broad strategy for Indian banking industry that can address the chronic issues (like, economic slowdown, mounting NPAs, poor credit off-take etc.) while at the same time ensure sustained growth and profitability without compromising on asset quality? What strategy could create more employment avenues and revival of key sectors of the economy? What are the implications of ICT adoption in retail banking? In line with the research questions, the objectives of this paper are: (i) To study the relevance of promoting retail banking by banks in India with a focus on housing finance, with due emphasis on more ICT adoption; (ii) To study the need for ICT-integration by banks, especially in their retail banking portfolio, and its implications; (iii) To suggest the medium-term banking strategy for India, that is in line with the national goals of ‘Housing for All by 2022’ and ‘Digital India’. This study is of descriptive-analytical nature and is exploratory. It uses secondary data from authentic sources. The theoretical model is the use of linkages of housing and ICT for sustained economic growth.



5. Relevance of Promoting Retail Banking with a Focus on Housing Loans

There is a steadily falling trend in GDP growth rates over the last few years. This trend is very clear since FY 2017 onwards (Figure I). This falling trend is more pronounced since the first quarter of FY 2018-19 till the first quarter of FY 2020, and this trend continues. (Figure II).

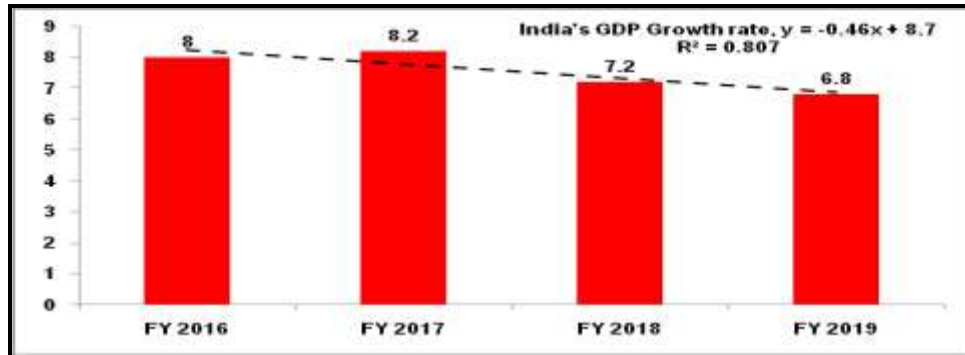


Figure I: India's Annual GDP growth rates. (Source: CRISIL 2019)

The gradually falling GDP growth rates in India, both in the short term (Figure II) and also in the intermediate term (Figure I), definitely suggests economic slowdown and the need for suitable counter cyclical as well as structural policies that can reverse the declining trend by kick-starting the recession-hit sectors of the economy and hence reviving the whole economy.

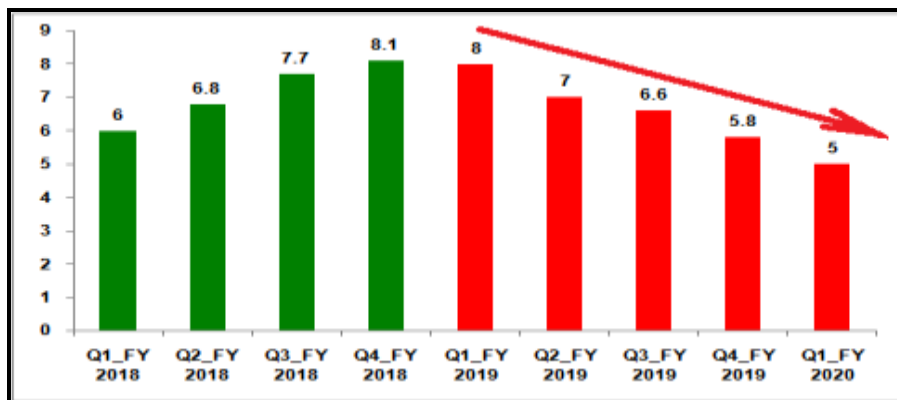


Figure II: India's Quarterly GDP growth rates. (Source: CRISIL 2019)

Retail credit, particularly housing loans portfolio within it, has got the capacity to generate more demand by way of creating multiplier effects because of its vast linkages with nearly other 300 allied industries. Besides a basic necessity of human life, housing is the most prominent activity under the construction sector which in turn accounts for over 50 percent of the developmental outlays of the government. A HUDCO-sponsored study to assess the impact of housing investments on employment and GDP has noted that housing sector ranks third among the major 14 sectors in India in terms of linkage effects with other sectors of Indian economy. It is reported that in respect of income multiplier housing sector ranks fourth and that it is ahead of other sectors like transport and agriculture. It is reported that unit rise in final expenditure on housing would create additional income of nearly 5 times. So, housing sector in India plays a major role by contributing to employment and income generation. A new revival package of Rs.20,000 Cr. for unfinished housing announced on 14th Sept. 2019 acknowledges this vital fact.

Housing investments help not only the respective individuals directly but the socio-economic development of the whole nation as well. So, governmental policies on housing have vital impact on the national economic development besides the social and familial wellbeing of the citizens. Because of this fact housing is often called the growth engine for developing nations like India. Given the low mortgage to GDP ratio in India of about 9 percent which is one of the lowest in the whole world, there is enormous scope for the housing finance sector to grow in India (Table I). In a period of economic slowdown as faced by India at present, banks and other players like NBFCs have the responsibility to focus on housing finance for their own growth as well as the wellbeing of the shelter-less public and the national economic development. (Table I).

Table I: Mortgage to GDP Ratio of India (2012) vis-a-vis Selected Other Countries

(In Percentages)

India	China	Thailand	Korea	Malaysia	Singapore	Taiwan	Hong Kong	USA	UK
9.0*	12	17	26	29	32	39	41	80	86

Source: European Mortgage Federation (2007), ADB (2007), and NHB (2013).

Note: * NHB, as of 2012, *Report on Trend and Progress of Housing in India 2013*, p.105.

The housing loan market in India has been growing over the years and the trend is likely to continue in the future also; the two major players in this market being Commercial Banks (or, Banks in short) and Housing Finance Companies (or, HFCs, in short). (Figure III).

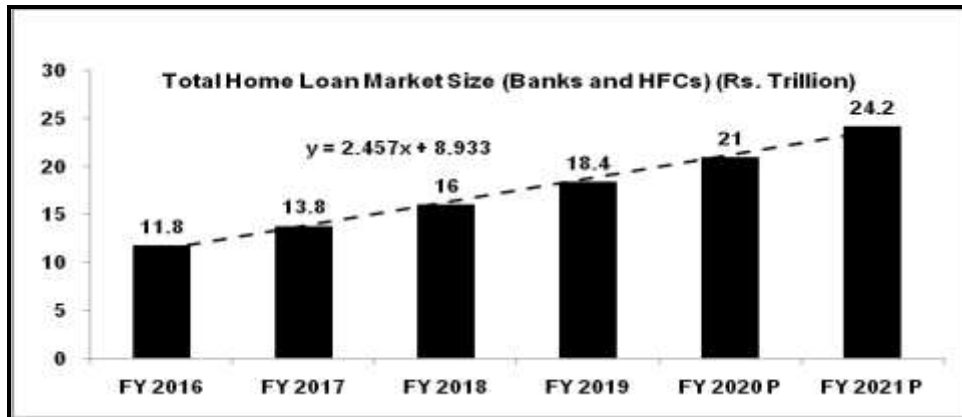


Figure III: Total home loan market (HFCs and Banks) in India (Rs. Trillion)

Source: Computed from CRISIL data (2019) [4]

6. ‘Housing for All by 2022’ Regime: Greater Role for Banks in Housing Finance

In India, the two major players in the housing finance market are banks and HFCs. Of these two major players, the relative market share of HFCs is estimated to gradually come down because of the liquidity crisis faced by the NBFCs in general and HFCs in particular, in the aftermath of IL & FS fiasco. The chronic issues faced by Dewan Housing Finance Corporation (DFHL) – one of the prominent HFCs in India, and the mounting problems with Indiabulls Housing – another major HFC in India are just two examples to the multifarious issues that HFCs in India currently face. All the HFCs, both large sized as well as the mid-sized and small sized ones, face the problem of dwindling profitability because of growing cost of funding, deteriorating asset quality, lower growth rates and hence lower relative market share vis-à-vis the banks, and so on. The issues faced by HFCs, like growing borrowing costs, is more in respect of HFCs with ALM (Assets Liability Mismatch) issues and/or poor asset quality. Consequently, HFCs rely more on long term bank loans for their funding. (RBI, FSR, June 2019, p.17) [32].

Contrary to the case of HFCs, banks have better liquidity. Besides, the Government has announced a new package of Rs. 70,000-00 Crore for the public sector banks (PSBs) in India on 23rd Aug. 2019. While the relative prominence of HFCs is falling and so is their market share, that of banks is rising and so is their market share. As the national goal of ‘Housing for All by 2022’ is in place, banks in India have a greater responsibility in attaining this goal. (Figure IV).

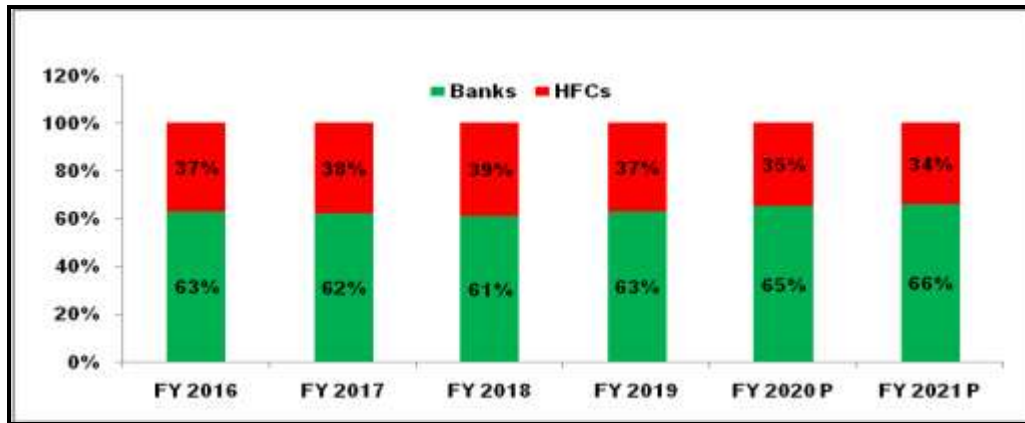


Figure IV: Growing share of Banks and falling share of HFCs. (Source: CRISIL, 2019 [4])

In view of the liquidity issues and other problems faced by the HFCs in India, banks will have a greater role in the housing finance market in the days to come. It is noted that banks would have much higher growth prospects than the HFCs, because of a reversal in the growth rates of HFCs vis-à-vis Banks since FY 2019. The responsibility that banks have to shoulder so as to attain the national goal of ‘Housing for All by 2022’ is of higher order now. (Figure V).

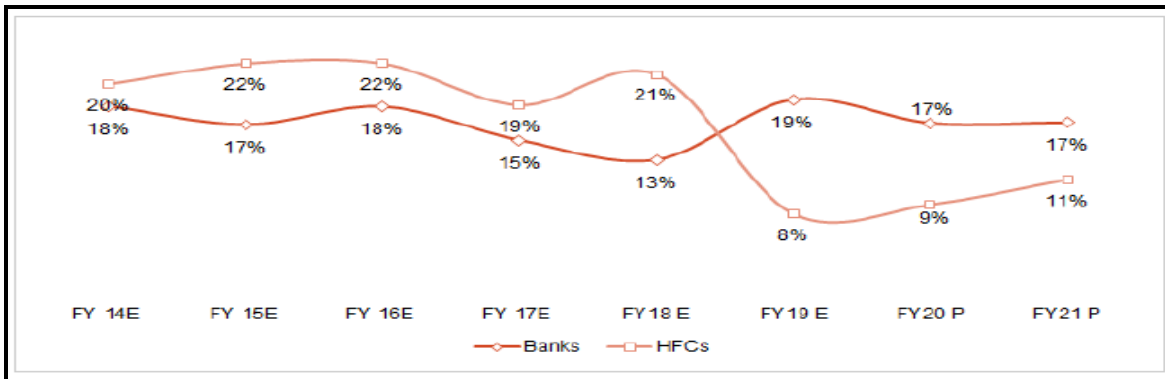


Figure V: Healthy Growth Prospects of Banks vis-à-vis HFCs. (Source: CRISIL, 2019 [4]).

Of late, the RBI’s directive dated 04th Sept. 2019 has made it mandatory for all banks to link new floating rate loans to retail customers (and also MSMEs) to an external benchmark from 01st Oct. 2019. The external benchmark could be the policy repo rate, yields on 91-day and 182-day treasury bills (T-bills) as published by the Financial Benchmarks India Private Ltd. (FBIL), or any other benchmark rate published by FBIL. Henceforth, banks will have to reset their rates once in every three months. RBI has allowed banks to add a spread over the benchmark rate chosen by them, so as to enable them to cover the risks and costs associated with rate changes. This shift is the latest one in the series of many such shifts, like, the Prime Lending Rate (PLR) of 1994 gave way to Benchmark Prime Lending Rate (BPLR) in 2003, to Base Rate System (BRS) in 2010, and then to Marginal Cost based Lending Rate (MCLR) in 2016. The latest rate-policy (based on external benchmarks) will be applicable from 01st Oct. 2019. (Figure VI).

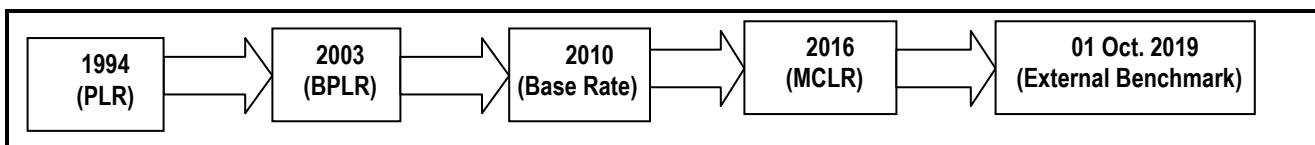
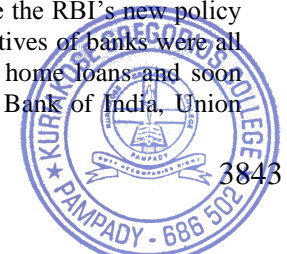


Figure VI: RBI’s Policy Shifts on Lending Rates (1994-2019) (Source: Author’s compilation).

The current policy directive of the central bank seeks to achieve better transmission of its monetary policy, and will have unprecedented repercussions on the retail banking landscape in India in the days to come. In fact, it may be noted that some banks had already started rates based on external benchmarks (like, Repo); even before the RBI’s new policy announced 04th Sept. 2019– which made such transmission mandatory. But, such voluntary initiatives of banks were all of optional in nature. SBI was the first bank to offer such loans when it offered Repo-linked home loans and soon afterwards many banks, mostly the public sector banks (PSBs) followed suit. So, IDBI Bank, Bank of India, Union



Bank of India, Central Bank of India, United Bank of India, Allahabad Bank etc. too started offering similar Repo-linked home loans. But, the latest policy of the RBI being of mandatory nature, all players must follow it. As per this policy, existing loans linked to the MCLR/Base rate/PLR shall continue till repayment or renewal as the case may be. Those customers, if desirous of switching over to the new rate, can do so on mutually acceptable terms. Borrowers of retail loans like home loans can avail these at lower rates and also enjoy other benefits accruing from the new policy from 01st Oct. 2019. (Table II).

Table II: Benefits to Customers of housing loans and such other retail loans.

MCLR-based Regime (till 30.09.2019)	External Benchmark Regime (from 01.10.2019)
Linked to Cost of Funds of banks.	Linked to RBI's lending rates (like Repo).
Takes 4-6 months to move after RBI's rate cut (i.e. longer transmission time).	Responds immediately to RBI's rate cut. (i.e. very short transmission time).
RBI rate-cuts not fully passed on to borrowers	RBI rates cuts are automatically passed on.
Resets annually for most banks	Reset every three months
Changes by 5 to 10 basis points (bps)	Usually changes 25 basis points (bps) or more
Revised every month	Reviewed bi-monthly
Low volatility	Higher volatility.

Source: Adapted from, *The Times of India* (Daily), Kochi Ed., dt. 05.09.2019. [Print]

Despite the benefits of customers, the profit margins of banks and HFCs will be under pressure in a competitive scenario. Closer control of costs and asset quality would be vital for offering loans at reasonable rates to the customers, and only players with good financial health can ensure this. Banks are already grappling with high deposit costs, and most of them are burdened with the problem of stressed assets too. So, they will have to charge higher spreads to protect themselves. Most HFCs have liquidity problems and issues like mounting funding costs. In fact, the HFCs will be more severely affected by the above move. Share prices of HFCs fell sharply on 05th Sept. 2019 after the RBI's policy directive on 04th Sept. 2019. A few banks with high housing finance exposure (ICICI Bank, SBI etc.) too lost dearly in share prices owing to RBI's new policy of setting loans rates using external benchmarks, like, Repo rate. (Table III).

Table III: Sharp Fall in the Share Prices of HFCs and Banks after RBI's Policy Directive

Sl. No.	Names of the prominent Housing Finance Companies (HFCs) and Banks in India	Fall in share prices after RBI's policy-shift (on 04.09.2019)
01.	LIC Housing Finance Ltd.	-03.87 percent
02.	HDFC	-02.67 percent
03.	Indiabulls Housing Finance Ltd.	-02.25 percent
04.	Gruh Finance Ltd.	-02.27 percent
05.	Can Fin Homes Ltd.	-02.09 percent
06.	PNB Housing Finance Ltd.	-01.54 percent
07.	Repc Home Finance Ltd.	-01.18 percent
08.	ICICI Bank (ICICI Home Finance is Sole Sales Agent)	-02.16 percent
09.	SBI (SBI has a very vibrant housing finance portfolio).	-00.65 percent

Source: Prasad R. R., *The Deccan Chronicle* (Daily), Kochi Ed., dt. 06.09.2019 [Print]

HFCs will be more adversely affected by the latest RBI's policy on lending rates. HFCs have already been losing their market share to banks. They will lose more in the future because the competition between HFCs and banks will become more intense in the future. though banks would definitely retain their upper hand in the market share. Besides, the current state of affairs would further accelerate the general trend of constantly narrowing down gap between systemic credit growth and banking credit growth, from FY 2017 onwards. (CRISIL, 2019)(Figure VII).



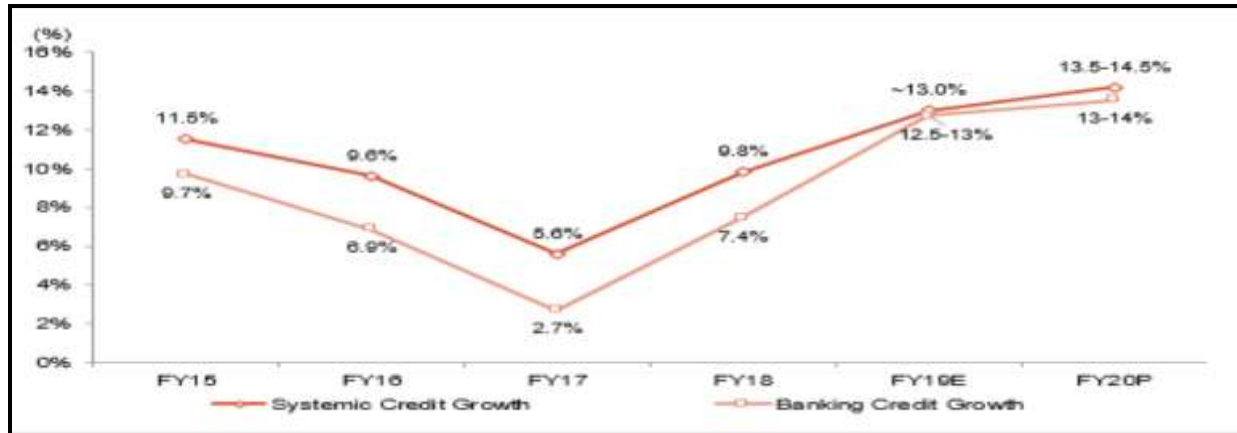


Figure VII: Systemic Credit growth and Banking credit growth (Source: CRISIL, 2019).

The spread between systemic credit growth and banking credit growth would further narrow down in the future because of the deceleration in the credit off-take from HFCs and other NBFCs. Housing credit and other retail advances would act as the most important element that propel the banking credit growth. This trend needs further push because of two facts. First, the economic slowdown in India needs to be corrected and the peculiar features of housing investments (like, linkage effects) should be utilized meaningfully. Secondly, even today the credit penetration in the household sector is very low in India, compared to the global peers. In fact, there has been a constantly rising trend in the household debt to GDP ratio in India. Still, there should be conscious efforts to further increase this ratio, by way of promoting housing credit and other retail advances so as to tide over the present economic slump. (Figure VIII).

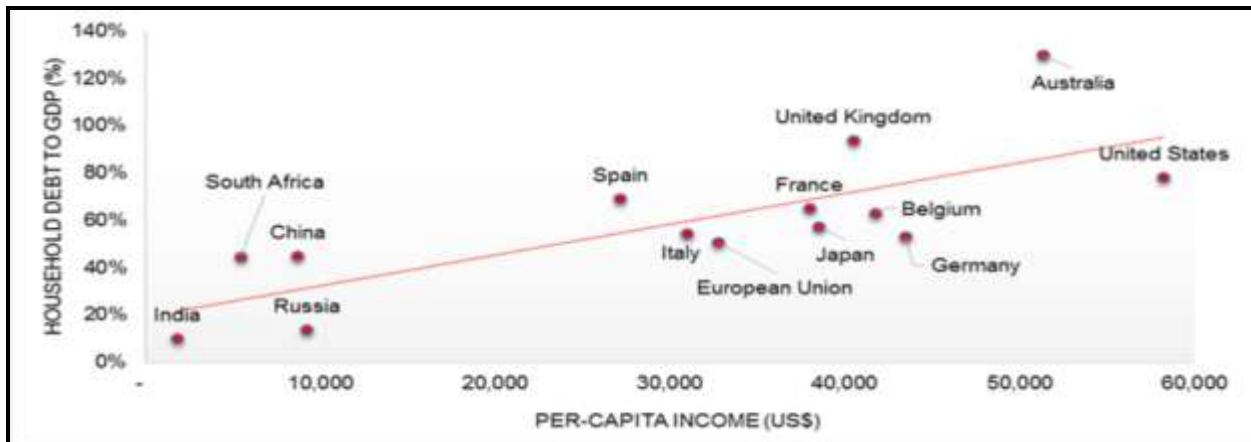


Figure VIII: Credit penetration in Household sector: India Vs. Peers (Source: CRISIL, 2019).

It has further been observed that the problem of bad debts associated with large corporate lending is not there in the case of retail loans like housing finance. Housing finance, in particular, has got one of the least amounts of bad debts. Similarly, in respect of the occurrence of frauds in banking too, cases of frauds in respect of housing loans are very less. In fact, there has been an alarming rise of 73.8 percent in the amount involved in frauds as of FY 2019 (Rs.71,542.93 Cr.) compared to the respective amount in respect of FY 2018 (Rs.41,167.04 Cr.). It has also been reported that frauds relating to card/internet-related transactions and deposit-related transactions constituted only 0.3 percent of the total frauds in value terms. (RBI, 2019) [36].

As the public sector banks (PSBs) in India are undergoing a phase of consolidation, many smaller PSBs have either been merged with larger PSBs (anchor banks) or are in the process. For instance, Bank of Baroda (BOB) has recently acquired Dena Bank (DB) and Vijaya Bank (VB). Now, BOB alone exists as a larger entity and DB and VB have vanished. The latest is the move to consolidate 10 other PSBs, so as to retain just four larger PSBs alone viz. (i) Punjab National Bank (PNB), (ii) Canara Bank (CB), (iii) Union Bank of India (UBI), and (iv) Indian Bank (IB). Given the diverse asset profiles of the merging entities, the only commonality is in retail credit. Hence, promoting retail credit is the only feasible option before the PSBs during the current phase of consolidation. Only after attaining normalcy in ICT integration and HR integration, the PSBs can think of large-sized loans, like, corporate or industrial loans, because PSBs are already facing the huge burden of bad debts (NPAs) in such kinds of advances. While promoting the retail advances

like housing loans also, PSBs have to focus on better ICT integration so as to offer value-added services and also to constantly innovate their products and services with a view to offer ‘As you like it’ products to the modern discerning customers who will always seek ‘Something extra’ from among the various products on the offer. Here, PSBs can maintain their competitiveness only by way of greater ICT integration, constant skill updation for the staff etc.

Given the national goal of ‘Housing for All by 2022’ and the fact that Indian economy is passing through a recessionary phase, the need for promoting banking credit in general and housing credit and other retail loans in particular need not be overemphasized. Despite the narrowing down gap between systemic credit growth and banking credit growth and also the growing credit penetration in household sector, there should be conscious attempts to further speed up these positive trends for faster development of the recession-hit Indian economy. ICT adoption by banks is not just a choice but an imperative that can accelerate the above process.

7. Better ICT Integration by Banks in ‘Digital India’ Era: The Need and Implications

Reforms initiated in Indian banking sector since 1992 has resulted in this sector, which was overwhelmingly dominated by the Government-controlled Public Sector Banks (PSBs) and significantly oriented towards fulfilling certain social obligations till then, to work on business lines. Like private sector banks and foreign banks, PSBs too started working on business lines, based on profitable business models. The pressures of ‘LPG’ (Liberalization, Privatization and Globalization) could succeed in injecting ‘commercial sense’ and ‘profit orientation’ in Indian banking sector, primarily the PSBs. LPG has brought about fierce competition too. To withstand competition and to maintain profitability and market share in the globalised markets it has become essential for banks to deliver high quality service at low cost. The real impetus towards ICT adoption in India was basically the banking sector deregulation measures initiated in 1992.

A serious thrust on ICT adoption was given by the Reserve Bank of India (RBI) only in 1999-2000, because of two reasons. First, for the specific purpose of a smooth transition for the year 2000. Second, for the general purpose of ensuring overall technological upgradation of Indian banks essentially to facilitate payment and settlement, enhanced customer service and profitability. Of late, the Demonetisation (DeMo) drive since 08th Nov. 2016 by the Government of India has given another impetus for ICT adoption by banks. Modern customers being very discerning, customer centricity is a vital need for business success. So, ICT integration has become an imperative for survival and growth, particularly in respect of retail banking products. The growing trend of ICT adoption in the ongoing era of ‘Digital India’ has vital impact on the operations and business models of banks in India. The rapid pace of technological innovations would radically change their business models for retail banking including housing finance. Indian banking sector has been following the above global trend only since the 2000s. Of late, the ongoing consolidation process among the PSBs has given another need for ICT integration.

Though, Indian banks have been quite late in adopting ICT and other technological innovations, of late, there has been growing adoption of digital banking by banks in India. (Figure VI). BCG’s report (2018) [2] has noted that digital banking will exceed USD 1 Trillion over the next 5 years, and that retail banking portfolio of banks has witnessed a CAGR of about 16 percent over the last 5 years. It is noted that total retail loans that could be disbursed digitally in the next 5 years would be over USD 1 Trillion and that annual disbursements 5 years hence would be 5 times of current levels. (BCG, 2018)[2].

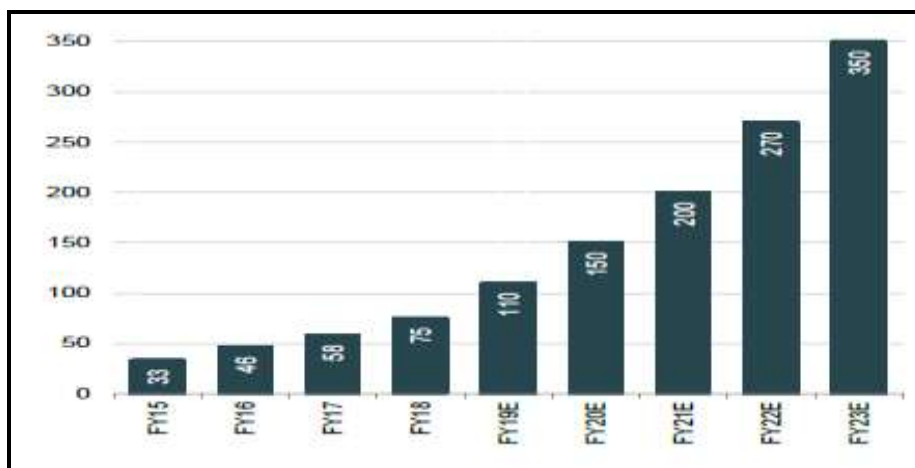


Figure VI: Digital Lending by Banks in India (USD Billion). (Source: BCG, 2018)[2]



BCG’s study has noted that the digital footprint (i.e. access to internet) of customers in the financial services category is 50 percent. Of the customers with digital footprint, 55 percent have been noted to be digitally influenced. That is, 28 percent (i.e. 55 percent of 50 percent) of the total population are digitally influenced. Besides, of the customers with digital footprint, 47 percent are digital purchasers. Thus, 23 percent (i.e. 47 percent of 50 percent) of the total population are digital purchasers. That is, as high as 82 percent of the digitally influenced customers are digital purchasers. So, the drop-off is very less. (Figure VII). (BCG, 2018) [2].

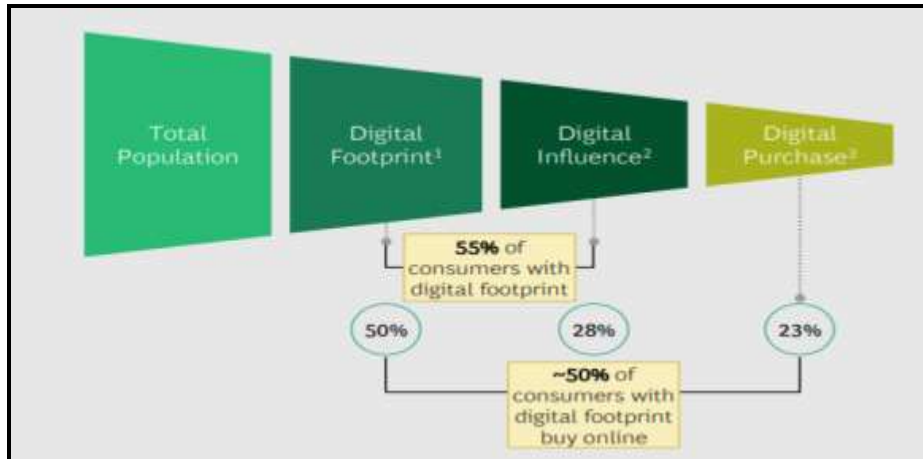


Figure VII: Nearly one-fourth (23 percent) customers purchase retail loans digitally. (Source: BCG Google 2018 Digital Lending Survey (N=2364)[2].

ICT-based delivery channels like mobile banking and phone banking is vital to lure the modern customers. The constant rise in per-capita E-transactions in India is an indicator of the growing customer preferences towards ICT-based transactions. (Figure VIII).

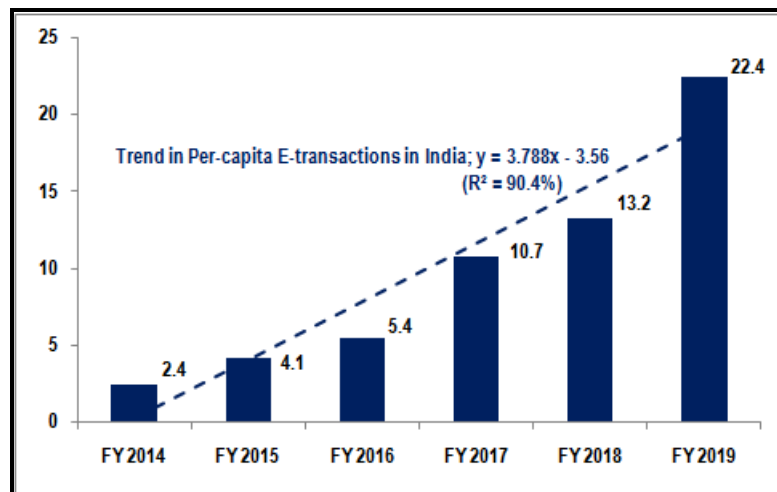
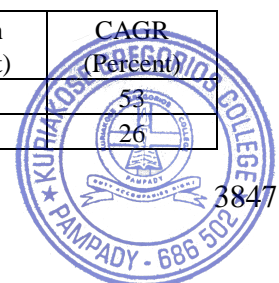


Figure VIII: Trend in per-capita E-transactions in India. (Source: RBI, 2019 and Bloomberg).

The recent data on different modes of transactions indicate that there is a growing trend in respect of digital mode transactions whereas there is a gradual fall in the conventional mode (Cheques) transactions. Just like the fast growing trend in per-capita E-transactions (Figure VIII), there is a growing interest in digital transactions. This is another indicator of the need for adopting ICT-based channels, especially for the retail banking products. (Table IV) (Figure IX).

Table IV: Growth in Digital Transactions (FY 2015-2019)

Sl. No.	Type of Transactions	Volume (Million) FY 2015	Volume (Million) FY 2019	Growth (Percent)	CAGR (Percent)
01.	Card Payment*	808	4414	446	53
02.	NEFT	928	2319	150	26



03.	RTGS	88.4	133.3	51	11
04.	Card (at ATMs)	7001	9869	41	9
05.	Cheque	1197	1124	-6	-2

Source: Compiled from RBI, 2019 [36]

* Includes Card payments (except at ATMs), both debit and credit, like, PoS, e-Commerce etc.

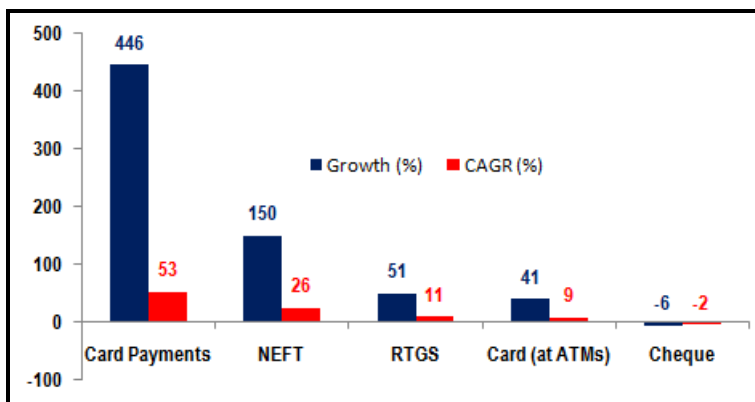


Figure IX: Growth in Digital Transactions (FY 2015-2019)
(Source: RBI, 2019)[36]

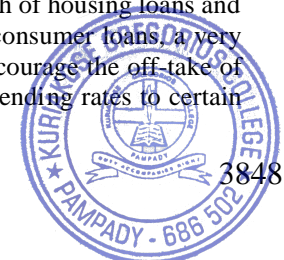
A clear and fast transition towards digital mode transaction, particularly by way of using cards, NEFT and RTGS is noted while those through cheques are gradually falling. (Figure IX). From the above discussions, it may be noted that banks in general and PSBs in particular have to integrate ICT in their all their products and change their business models accordingly. Apart from ICT adoption, equally important is the need for constant product and process innovations.

8. Medium Term Strategy for Banks in ‘Digital India’: Some Broad Suggestions

Given the national goal of ‘Housing for All by 2022’ in India and also the ‘Digital India’ initiative that is going on throughout India, let us now try to design the medium term strategy for the banks that can take care of the national goals and at the same time help tide over the present situation of economic slowdown. Whether the economic slump is cyclical or structural in nature, investment in housing can act as a suitable remedial strategy. So, promotion of retail credit by banks, particularly housing credit is meaningful, especially when we consider the vast linkages of housing industry with nearly 300 other industries. Investment in housing can kick-start many a recession-hit sector in the economy and is a top employment generator also. Hence, the medium term banking strategy should be that of ‘retail credit with housing finance thrust’. Another vital need for the banking strategy is that of ICT integration. ICT ensures better competitiveness, significantly improve operational efficiency by reducing cost, and can enable better customer service also. Modern ICT-based tools like data mining can be of immense use because of their ability to generate relevant knowledge from large amounts of unorganized business data.

Given the imminent invasion by the financial technologies (Fin-Tech) companies and also the ever growing expectations of today’s discerning customers, banks have to constantly innovate their products and services, particularly in respect of the retail banking portfolio. Here, ICT acts as the means (enabler) as well as the end. Thus, from the perspective of competition also ICT integration at all levels, especially in retail banking segment, is an imperative for the survival and growth of the banks in India. PSBs need to be especially cautious in this regard. As consolidation is going on among the PSBs, the latest being the consolidation among 10 PSBs with a view to retain the large 4 PSBs alone (viz. PNB, CB, UBI and IB), the only feasible strategy that can ‘keep them moving’ in the short and medium terms is that of focusing on retail credit with due respect to ICT integration and constant product innovations. Focusing on large corporate or industrial advances or on project financing by these PSBs which are already heavily burdened with the issues of bad-debts (NPAs) and falling profitability and productivity will not at all be sensible in the short or medium term. Identifying their synergies and designing suitable business models would require some more time during which they can focus on retail credit.

The policies of the Government of India as well as the RBI have been conducive for further growth of housing loans and other retail advances. For instance, on 12th Sept. 2019, the RBI has reduced the risk weight on consumer loans, a very popular retail credit product, from the earlier 125 per cent to 100 per cent. This policy would encourage the off-take of consumer credit. Another policy directive of the RBI that mandates all the players to link their lending rates to certain



specified external benchmarks (like, Repo rate) would also be beneficial to banks in the long run, because more customers would be interested to avail retail loans as the lending rates become more transparent as well as responsive to external benchmarks. Of late, on 14th Sept. 2019, the Government of India has announced a special package of Rs. 20,000 Cr. to provide last-mile funding for completing the unfinished housing units (non-NPA and non-NCLT cases alone) of affordable and middle income housing projects. Relaxing the norms for raising funds through external commercial borrowings (ECBs) is another incentive for the housing sector. Besides, the interest on House Building Advance (HBA) of government servants is now reduced. The booster dose declared on 14th Sept. 2019 as above would certainly revive the housing sector.

Use of advanced ICT platforms that can support competitive tools like data mining and knowledge discovery is very desirable for any progressive bank for its survival and growth. Such a platforms enable high level of customer engagement and facilitate targeting different customer segments with tailor-made products. Modern payment technologies like RFID (Radio Frequency Identification) need to be adopted to remain competitive in the market. ICT investments, further, should focus on improving responsiveness, resiliency and enterprise-wide collaboration. Strategic tie-ups and resource sharing among the banks can bring in enhanced efficiency in the use of technology. This is especially relevant for the PSBs which are undergoing consolidation.

Customer centricity has a vital role to play in banking industry in the future. Sustainable business models that ensure continued customer loyalty or long term relationships have to be followed consistently by all banks, including the 'traditional' banks like PSBs.

Because of the fast advances in ICT and also the discerning nature of modern customers, innovation of all types on an ongoing basis is a vital for retaining and attracting the customers. So, each and every product needs to be designed meticulously based on a clear understanding of the customer's quality value proposition. Banks need to focus on specialized customer segments, as a 'one-size-fits-all' policy no longer appeals the customers of today's globalized markets. To identify the target customer segments banks have to adopt scientific market research studies and use advanced ICT tools like data mining.

Given the discerning nature of modern customers, more high technology (Hi-Tech) products and delivery channels are imperatives for survival and growth, rather than options. The growing trend in computer literacy and the ever-growing affinity to modern products among the younger generation make the above strategy more meaningful. Also, it is essential to effectively defend the threat by specialized (niche) players, including the Fin-Techs which are growing fast.

With growing adoption of ICT-based applications by banks, there are mounting trend in scams, information/cyber security issues, data leakages, frauds etc. So, setting up robust systems for risk management relating to information/cyber security should be a top priority for all banks.

Encouraging a dynamic secondary market for housing finance, like, residential mortgage backed securitization (RMBS) is yet to emerge in India. The Government has to facilitate a vibrant RMBS market in India so that it acts as a new source of finance for the housing sector, particularly for the HFCs which are grappling with liquidity problems. The IL & FS fiasco and DHFL crisis have worsened the case of NBFCs, especially the HFCs. Equally important is the need to promote the real estate investment trusts (REITs) in India. The IPO of India's first REIT (viz. Embassy Office Parks) being oversubscribed on 01st April 2019 being a grand success, more players are about to launch fresh REITs. This in turn would promote the commercial real estate directly and residential real estate too, indirectly. Conscious efforts for encouraging the market innovations like RMBS and REITs are required in India for housing development.

Whatever may be the level of ICT adoption, any banking service needs to have a human touch in order to be holistic and comprehensive. This 'human factor' in banking services must ensure adequate customer touch points for all products by way of meticulous planning.

All the above strategies have direct impact on the technological platform of the respective banks. A few other relevant strategies that can ensure superior performance of banks include, inter alia, enhanced transparency and strict corporate governance, enlarged accountability, adoption of international standards in accounting and reporting etc. More flexibility in human resource management (HRM) policies is required, especially for the PSBs. This would enable low cost and more flexible labour options like off-shoring. Besides, provisions to attract and retain the talent are required, which in turn may need more functional autonomy for the banks.

Concluding Remarks

In spite of issues like growing NPAs, need for recapitalization etc., particularly for the public sector banks (PSBs) in India, it may be noted that still Indian banking system is adequately stable, resilient and reasonably equipped to comply



with global regulatory norms. When NBFCs (including HFCs) are grappling with problems of liquidity, asset-liability mismatch, falling profitability and so on, banks in India are still healthier and more stable. The favourable governmental policies (for instance, capital infusion Rs. 70,000 Crores into PSBs in Aug. 2019) have added to the strength of banks in India. However, banks in India have to play a greater role in the current situation of the country that is characterized by economic slowdown. Almost every sector in the economy facing a slump, and the case of NBFCs (including HFCs) is no exception.

Notwithstanding the fast growth of digital transactions in India, regarding ICT adoption by banks in India, there appears to be good scope for improvement, particularly in respect of PSBs – still the backbone of the Indian banking system, in spite of their losing prominence. In fact, ICT upgradation and consolidation in banking industry are mutually reinforcing in nature and results in significant cost savings for the respective banks, mostly the PSBs. Need for restructuring the banks by adopting stronger customer orientation with robust technological platform assumes vital significance today. The recent governmental policies are all in the right direction.

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Volume 6, Issue 2 (XXXXI)
April - June 2019

ISSN 2394 - 7780



ज्ञान-विज्ञान विमुक्तये
UGC
University Grants Commission
Journal No.: 63571

International Journal of Advance and Innovative Research

Indian Academicians and Researchers Association
www.iaraedu.com



Released on 12th June 2019

International Journal of Advance and Innovative Research
Volume 6, Issue 2 (XXXXI): April - June 2019

ISSN 2394 - 7780

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Journal - 63571

UGC Journal Details

Name of the Journal : International Journal of Advance & Innovative Research

ISSN Number :

e-ISSN Number : 23947780

Source: UNIV

Subject: Multidisciplinary

Publisher: Indian Academicians and Researchers Association

Country of Publication: India

Broad Subject Category: Multidisciplinary



REAL ESTATE INVESTMENT TRUSTS (REITS): FOR CONSTRUCTING A ROBUST FOUNDATION FOR HOUSING AND REAL ESTATE SECTOR IN INDIA**Dr. Manoj P K¹ and Dr. Mini Joseph²**Assistant Professor¹, Department of Applied Economics, CUSAT, KochiHead², P. G Department of Commerce & Research Centre, K. G. College, Pambady, Kottayam**ABSTRACT**

In the context of the national goal of 'Affordable Housing for All by 2022' in India, construction of houses and other residential buildings is of vital significance. Apart from meeting the primary social goal of housing for all, housing investments will lead to faster national economic development too, because of the vast forward and backward linkages resulting from housing investments. The successive Governments in India have been making huge investments, both direct and indirect, for housing development in the country. Large budgetary provisions for housing and extension of various incentives and subsidies to lenders and individual borrowers have been continuing over the years. Given the paucity of Governmental funds, however, there is always the need for participation by the private sector and also the public funds mobilized through capital market. Then only the huge investments required for materializing the dream 'Housing for All by 2022' can be mobilized. There has been appreciable growth in the Indian capital market in the past one decade, particularly in the Mutual Funds (MFs) industry. While the MF industry has been growing fast since the 2000s as it witnessed many innovations, this growth has further accelerated since 2017. Despite the high growth in the MF industry in India, instruments that are very similar to MFs viz. Real Estate Funds (REFs) and its variants like Real Estate Investment Trusts (REITs) are yet to pick up momentum. In India REFs and its variants such as REITs have excellent growth prospects because mortgage penetration in the country is very low. The first REIT issue in India (Embassy Office Parks) has been very successful. If properly developed, REITs can effectively support the growth of housing and real estate sector in India. Securities and Exchange Board of India (SEBI) has been trying to develop innovative financing models like REITs over the years. This paper looks into the need for promotion of REITs in India for greater liquidity in the housing and real estate sector thus facilitating rapid economic development of the nation, and suggests suitable strategies.

Keywords: Real Estate, Housing Development, Linkages, REFs, REMFs, REITs.

1. INTRODUCTION

It is well recognized in the literature that housing and real estate sector has huge potential for economic development of any nation, apart from its social development role. This is particularly true in respect of developing nations like India. Firstly, the vast forward and backward linkages of housing and building construction industry with 269 other industries enable it to promote faster and balanced economic development of a nation. This industry has the potential to kick-start a recession hit economy too, because of the above linkage effects. Secondly, from a social perspective, housing is a primary requisite of human life and hence an essential ingredient in any welfare state. With the initiation of the economic reforms in India since July 1991, the housing sector has been getting added attention and more conducive environment for its growth, notwithstanding the fact that successive Governments used to accord high priority to this sector even before the reforms era, especially since the early 1970s. In the ongoing reforms era there are more business opportunities and added demand for commercial and residential space. This paper looks into the need for promoting real estate investment trusts (REITs) in India for the rapid faster growth of Indian economy.

2. LITERATURE REVIEW AND RESEARCH GAP

Kiran Keswani (1997) [11] in his paper, 'The contribution of building centres to low-cost housing in India' in *Building Research & Information* has studied the reasons for the slow growth in low-cost housing projects in India. The author has suggested that the Government should assume the role of a facilitator rather than a provider. A three-pronged strategy has been suggested for promoting low cost housing viz. (i) examining critically the archaic laws on housing, (ii) disseminating information on technical aspects of house building, and (iii) training in updated technologies on low-cost housing. Peer Smets (1999) [30], in his paper 'Housing Finance Trapped in a Dilemma of Perceptions: Affordability Criteria for the Urban Poor in India Questioned' in *Housing Studies* has argued that a definitional issue associated with formal housing finance and 'eligibility' for the same in terms of 'affordability criteria in one go' has resulted in exclusion of the vast majority of the urban poor from availing finance from formal sources of finance. The author has advocated the need for 'incremental housing' and also the need to assess the 'affordability in a phased in manner' and 'not in one go'. Manoj P K

(2003) [13] in his research paper, 'Retail Banking: Strategies for Success in the Emerging Scenario' in *IBA Bulletin* has suggested strategies for the sustained growth of the retail credit portfolio of banks, that mainly comprises of housing finance, as a safer way of increasing business and also kick-starting the then recession-hit industry of India. 'Linkages' – both forward and backward – of housing with large number of other industries, and the positive effect of such linkages for bringing about faster economic growth have been pointed out in the paper. Manoj P K (2004) [14] in his another research paper, 'Dynamics of Housing Finance in India' in *Bank Quest* has pointed out the growing appetite of commercial banks (CBs) towards housing credit, the falling share of housing finance companies (HFCs) in the market, and allied aspects. Some macro level strategies for the sustained and balanced growth of housing finance in India are suggested. The relevance of promoting secondary mortgage market (like, RMBS), alternative models like Housing Micro Finance (HMF) etc. in India has been noted.

In Working Paper 19 titled, *Housing Microfinance: Designing a Product for the Rural Poor*, released by Institute for Finance Management and Research (IFMR) (2007)[7], has noted the utmost importance of promoting Housing Micro Finance (HMF) – an alternative model for housing finance for the poor – for addressing India's chronic housing problem, which in turn is primarily that of the poor and marginalized in the country, like the LIG (Low Income Group) and EWS (Economically Weaker Sections). Only models like HMF could cater to such deprived sections that are not served by the formal sector agencies. So, models like HMF are required to solve India's 'real housing problem'. The IMFR report seeks to design the suitable HMF model for the Indian poor. Manoj P K (2008) [15] in his paper, 'Learning from Cross-country Experiences in Housing Finance: A Microfinance Approach' in *Journal of Global Economy* has suggested suitable macro level strategies for promotion of housing micro finance (HMF) in the Indian scenario by appropriately replicating the successful and time-tested models like HMF or other similar alternative housing finance models prevalent elsewhere in the world. In the edited book by Manoj P K (Ed.) (2009) [16], *Emerging Technologies and Financing Models for Affordable Housing in India* housing finance models and technologies for promoting affordable housing are explained. ICRA (2010) [6] in its research report on Housing Finance Companies (HFCs) in India has discussed the changing landscape of home finance market in the country, the greater growth rate and the gradual comeback of the HFCs vis-à-vis Commercial Banks (CBs), the superior asset quality and profitability of HFCs, etc. The very significant role that HFCs has to play in the emerging scenario to meet the huge housing shortage in the country has been highlighted in the study.

A research paper on HMF by Manoj P K (2010) [21], "Prospects and Problems of Housing Microfinance in India: Evidence from "Bhavanashree" Project in Kerala State" in *European Journal of Economics, Finance and Administrative Sciences* has studied in detail the utmost importance of HMF for balanced and equitable housing development in India, and hence rapid economic development of the country. Strategies for promotion of HMF in India have been suggested, along with specific and category-wise strategies for the HMF based in Kerala and sponsored by the state government namely 'Bhavanashree'. Manoj P K (2010) [18] in his paper, 'Benchmarking Housing Finance Companies in India: Strategies for Enhanced Operational Efficiency and Competitiveness' in *European Journal of Economics, Finance and Administrative Sciences* has made a detailed analysis of the relative competitive position of the leading housing finance companies (HFCs) in India and has suggested strategies for the enhanced operational efficiency and competitiveness of HFCs. The management consultancy organization, KPMG (2010) [11], in its Industry Report (Advisory), 'Affordable Housing – A key growth driver in the real estate sector?' has sought to discuss the immense growth prospects of real estate players in the affordable housing market in India, given the huge demand and grossly under-penetrated market, very favourable Governmental policies etc. The demand and supply constraints, the relevance of PPP in the real estate sector etc. have also been dealt in detail. In a research paper by Manoj P K, (2010) [19] 'Determinants of Successful Financial Performance of Housing Finance Companies in India and Strategies for Competitiveness: a Multivariate Discriminant Analysis' has attempted to find the determinants of superior financial performance of HFCs. Using the tool Multivariate Discriminant Analysis (MDA), Discriminant Function having five distinct parameters (selected from the total 21 parameters used for MDA) which significantly influence the financial performance of HFCs has been derived; these parameters being (i) Total Income to Housing Loan Assets, (ii) Other Income to Total Assets, (iii) Total Expenses to Housing Loan Assets, (iv) Interest Expenses to Housing Loan Assets, and (v) Interest Expenses to Total Expenses. Yet another paper by Manoj P K (2010) [17], 'Financial Soundness Housing Finance Companies in India and Determinants of Profitability: A 'CAMEL' Approach along with ROE Decomposition Analysis' has employed the methodology of 'CAMEL' ranking along with ROE decomposition analysis to identify the determinants of profitability of HFCs. A research paper by Manoj P K (2011) [22], 'Determinants of Profitability of Housing Finance Companies in India and Strategies for Competitiveness: a Multiple

Partial Correlation Approach' has suggested competitive strategies for various groups of HFCs with the help of the basic parameters that significantly influence the respective groups of HFCs.

A joint research paper by Hrushikesh Mallick & Mantu Kumar Mahalik (2015)[5] 'Factors determining regional housing prices: evidence from major cities in India', in *Journal of Property Research* has sought to identify the factors determining the housing prices with respect to 15 major cities in India using data relating to 16 Quarters (4 years, 2010 to 2013). It has been noted that fundamental factors are more significant than speculative factors. In a research paper by Manoj P K (2015) [25], "Socio-Economic Impact of Housing Microfinance: Findings of a Field-based Study in Kerala, India", published in *International Research Journal of Finance and Economics*, the reasons for the failure of 'Bhavanashree' – the HMF initiative of the Government of Kerala have been studied in detail. The author suggests strategies for effective implementation of HMF projects based on the "learning from the failure of 'Bhavanashree' project in Kerala. The research report by the agency IFMR (2015) [8] entitled *Affordable Housing Finance Sector: Overview* makes a detailed analysis of the need, relevance and significance of affordable housing in India in the context when the national goal of 'Affordable Housing for All by 2022' is implemented by the Government of India. The crucial role that HFCs have to play in this context is specially noted in the IFMR report. The fact that there is a gradual re-emergence of HFCs since 2013, thus overtaking the CBs in growth rate and significantly improving their market share has also been specifically pointed out. In a research paper by Manoj P K (2015) [23], "Deterrents to the Housing Microfinance: Evidence from a Study of the Bankers to 'Bhavanashree' in Kerala, India", in *International Research Journal of Finance and Economics*, the major problems associated by the bankers in financing 'Bhavanashree', the HMF initiative sponsored by the Government of Kerala, has been dealt in detail. Various issues like the unclear land tenure, fragile institutional framework of the HMF and its parent (mentor) 'Kudumbashree' etc. have been analysed in detail. The author makes a few suggestions to the Government based on the findings of his study, for the purpose of enabling it to more meaningfully implement HMF initiatives in the future, 'Bhavanashree' initiative being more or less a failure.

In a research article by Manoj P K (2015) [24], "Housing Microfinance: A Study on Quality, Cost and Default Rate with Respect to 'Bhavanashree' in Kerala", published in *International Research Journal of Finance and Economics*, a detailed and critical study of the asset quality, administrative (transaction) costs, and default rates in respect of the HMF initiative of the Government of Kerala viz. 'Bhavanashree' has been made. Accordingly, suggestions for more meaningful implementation of HMF projects by the Government have been made by the author. Another paper by Manoj P K (2016) [26], "Real Estate Investment Trusts (REITs) for Faster Housing Development in India: An Analysis in the Context of the New Regulatory Policies of SEBI" in *International Journal of Advance Research in Computer Science and Management Studies* has sought to make an exploratory study on the utmost relevance of REITs in a developing country like in India for the promotion of its housing and real estate sector and hence the economy as a whole. Industry research agency, India Brand Equity Foundation (IBEF) (2018) [6] in its report on Real Estate industry in India has pointed out the tremendous growth prospects of the real estate industry in India which is estimated to attain the size of USD 1 Trillion by 2030. Its estimated size as of 2019 is 3.7 Million Square feet and it is the fourth largest sector in terms of FDI flows. Rapid urbanization, growing affordability, and Governmental commitment towards 'Affordable Housing for All' etc. brighten the prospects of India's real estate sector.

In view of the foregoing discussions, it is noted that though there are a number of studies on housing in India, studies on REITs are virtually nil. The only exception is a recent study on REITs by Manoj P. K. (2016) [26], and the present study seeks to explore more into the study of Manoj P. K. (2016) [26] in the light of the latest developments like the first launching of REIT in India (viz. Embassy Office Parks REIT) which has been very successful.

3. RELEVANCE AND SIGNIFICANCE OF THE STUDY

Large-scale investments in commercial and residential properties in India is possible only through means like REITs. REITs can ensure faster development of housing and real estate sector (both residential as well as commercial) and hence overall economic development of the nation also. This is because of the vast forward and backward linkages associated with housing and construction activities. The very low level of investment in this sector in India at present points to immense growth prospects for REITs in the country. SEBI had initially issued a set of regulations for REITs in India in 2014. Further amendments have been done by SEBI in 2016. Of late, in 2019 SEBI has permitted online registrations for REITs and InvITs (Infrastructure Investment Trusts). With the overwhelming success of the first REIT issue in India on 01 April 2019 viz. Embassy Office Parks REIT, a joint venture between Blackstone and Embassy group, more players in this sector are about to launch

their REITs. This would provide growth momentum for the sector which is currently facing a slump. In this context an exploratory study of the prospects of REITs in India is relevant and significant.

4. OBJECTIVES OF THE STUDY

- (i) To study the relevance of REITs in India for providing a growth momentum to the housing and real estate sector which is currently in a stagnant stage;
- (ii) To study the evolution of REITs in India, the latest developments and innovations in the field, the current structure of REITs and also its future prospects and challenges;
- (iii) To suggest strategies for the effective promotion of housing and real estate sector in India through the REIT route, given the success of the first REIT launched in 2018.

5. METHODOLOGY OF THE STUDY

The present study is descriptive-analytical as well as exploratory in nature. The study is descriptive to the extent that it describes the developments in the field of real estate sector in India with a focus on the role of REITs in the faster development of this vital sector, and the implications of the latest developments in the field. Ever since the successful launching of the first REIT in India, SEBI has been coming up with innovations like online registrations for REITs and InvITs, relaxations in the norms of REITs etc. The paper is analytical too as it seeks to analyze the prospects as well as challenges of REITs in India in the days to come. The study is based primarily on secondary data from authentic sources like RBI and CRISIL.

6. NEED FOR INNOVATIONS IN THE REAL ESTATE SECTOR IN INDIA: THE CASE OF REITS

As the housing and real estate industry in India is currently facing a slump. But, the first issue of REIT has been a grand success and many new players are about to launch REITs. Hence, there is a need to sustain the interest of the investing public in housing and real estate sector. This in turn requires the continuation of constant product innovations. Equally important is the need to promote particular segments in this industry like REITs which have immense growth potential because of the very low mortgage penetration in India. (Table I).

Table-I: Mortgage to GDP Ratio of India (2012) vis-a-vis Selected Other Countries (In Percentages)

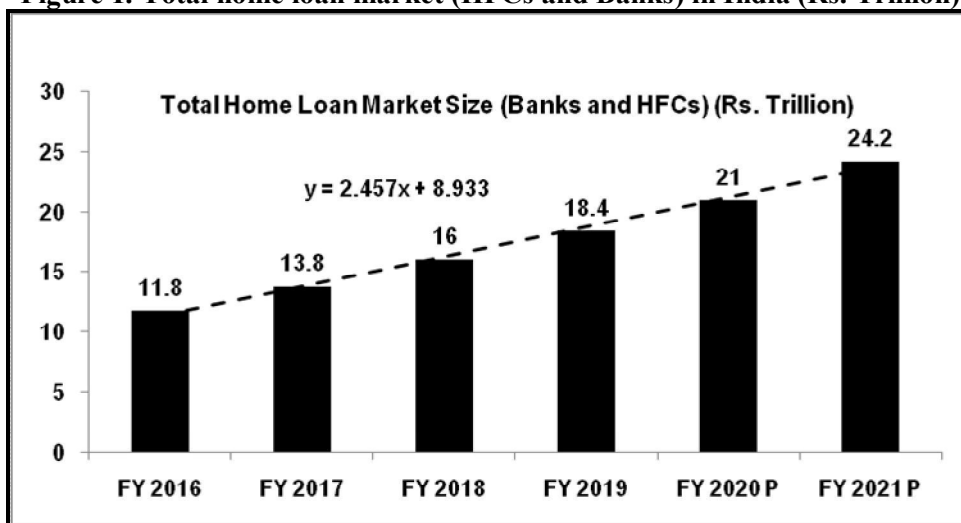
India	China	Thailand	Korea	Malaysia	Singapore	Taiwan	Hong Kong	USA	UK
9.0*	12	17	26	29	32	39	41	80	86

Source: European Mortgage Federation (2007), Asian Development Bank (2007) & NHB (2013).

Note: * NHB, as of 2012 (approx.), Report on Trend and Progress of Housing in India, 2013, p.105.

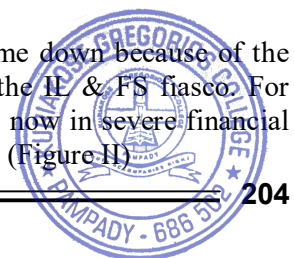
The housing loan market in India has been growing over the years and the trend is likely to continue in the future also; the two major players in this market being Commercial Banks (Banks in short) and Housing Finance Companies (HFCs, in short). (Figure I).

Figure-I: Total home loan market (HFCs and Banks) in India (Rs. Trillion)



Source: Computed from CRISIL data (2019) [4]

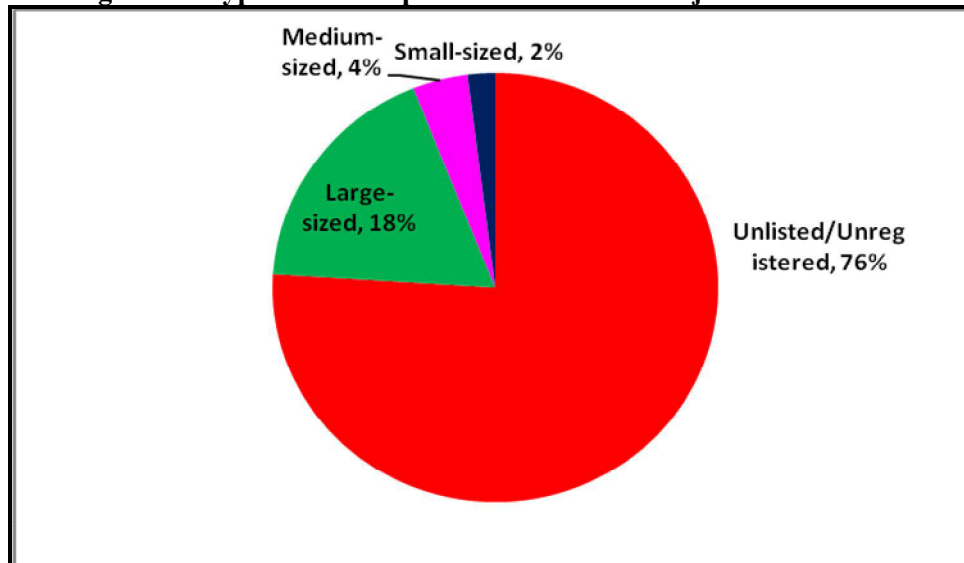
The market share of Housing Finance Companies (HFCs) in India is estimated to come down because of the growing liquidity crisis among the NBFCs in general and HFCs in particular, since the IL & FS fiasco. For instance, Dewan Housing Finance Corporation (DHFC), a prominent HFC in India, is now in severe financial crisis. The trend of diminishing market share of HFCs is likely to continue in the future. (Figure II)



With the implementation of Real Estate (Regulation & Development) Act, 2016 or RERA in short, a growth momentum is expected across all segments of the housing industry. This is because RERA enhances the transparency in the real estate transactions and protects the interests of the buyers or beneficiaries. In spite of some short-term hassles the developers of housing units, RERA would benefit them also in the long term because of greater business and better confidence of the customers as well as the investor public.

In the ongoing RERA era, a gradual consolidation is also expected leading a greater share for the organized players. At present, only about 24 per cent of the total market is owned by the organized players and the rest 76 per cent belongs to the unlisted and unorganized players. (Figure V). With the advent of RERA and the resultant compulsory registration for the players, the share of organized players would go up and so also transparency in dealings and confidence of the customers and investor public.

Figure-V: Types of Developers across the Ten Major Cities in India



Source: Compiled from CRISIL Report (2019) [4]

The above situation points to the high growth potential for REITs in India. The initial public issue by the first REIT (viz. Embassy Office Parks) in April 2019 has been very successful. Other major players are ready to come up with their REITs. The recent developments relating to REITs have been encouraging. SEBI has amended the REIT rules in 2016 and made it more flexible. Many relaxations were made. Of late, in 2019 SEBI has permitted online registration for REITs and this in turn would reduce the processing time and enhance the transparency in REITs dealings. Details are discussed later on in this paper.

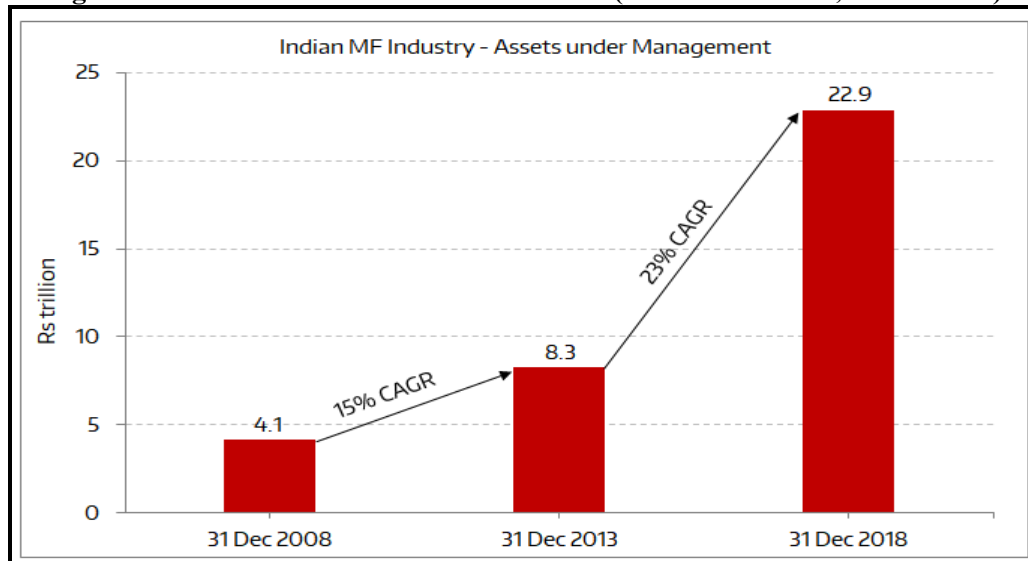
6. REAL ESTATE MUTUAL FUNDS (REMFS) AND REAL ESTATE INVESTMENT TRUSTS (REITS)

Real estate funds (REFs) are quite similar to the mutual funds and are founded by a group of real estate professionals to manage property for investors in such funds. Some other real estate funds do not actually own property and instead they opt to invest in bonds or instruments secured by property. In the former case, the investors or unit holders earn money by getting a share in profits from sale of property or from the rentals on property owned by them. In the second case, a coupon rate received on the investment in bonds or instruments is distributed among the investors or unit holders as dividend. The return from such investments is subject to any administration, management, brokerage and/or marketing fee charged by the REFs concerned. REFs have a longer lock-in period than equity funds. Maximum lock-in period for REFs is 6 years. Initially it was required to invest a minimum amount of 25 lakhs in the REFs. Naturally, the retail investors could not enter this segment and the potential investors in the REFs used to be commercial banks, financial institutions, high net worth individuals (HNIs) and corporate entities. However, later on the minimum amount to be invested was reduced to the level of Rs.10 lakhs. Still, REFs are beyond the reach of retail investor's viz. common investing public in India. Real estate in a broad sense includes commercial, residential, IT development, Hospitality, Malls and SEZ projects. So, REFs may target the development of all or any of the various real estate segments as noted above.

Real estate funds (REFs) or real estate mutual funds (REMFS) are often known, as real estate investment trusts (REITs) internationally. The essential difference between a REIT and a REF (or REMF) is that investments made in REIT are traded in real estate stocks and not invested in stock of companies. It provides a heavier

liquidity than MFs. While there has been appreciable growth in Mutual Funds (MFs) in India over the past one decade or more (Figure VI), it may be noted that REMFs or REITs are yet to pick up momentum.

Figure-VI: Trend in Growth of MFs in India (in terms of AUM, Rs. Trillion)



Source: Compiled from AMFI (Association of Mutual Fund Industry in India).

As per an earlier guideline by SEBI, the NAV of REMFs were required to be disclosed daily but later on there was a move for quarterly disclosure of NAV, thus drawing serious speculations in the realty segment. In India, REFs were initially launched in the REMFs format and later on in the form of REITs. Over the last one decade or more, SEBI- the regulatory authority for REFs and its variants in India, has been in the forefront for the regulation of REITs. Most funds operating in India have a lock-in period of 3 to 7 years. At the end of this period, the fund exits the holding by selling it in the secondary market. If the investment is in a commercial property, the fund may rent it out within the lock-in period and exit later. Most funds invest in residential projects and those commercial projects that are nearing completion. While residential projects move faster in the market, there is a rental yield attached to commercial projects. Because of the improved demand for housing and low capital requirement, often REFs focus on residential and income-generating commercial projects. A few funds invest in projects that are still in the initial stages of construction, based on saleability and track record.

7. GOVERNMENTAL EFFORTS TOWARDS REMFS AND REITS IN INDIA

In the recent years, the supportive policies of the successive Union governments in India have encouraged the liquidity flow into Indian real estate sector. For instance, Government of India has allowed non-resident Indians (NRIs) to invest upto 100 per cent as Foreign Direct Investment (FDI) in housing and real estate sector. This policy of 100 per cent FDI in the real estate sector in India, setting up real estate mutual funds (REMFS) coupled with other fiscal reforms like rationalization of stamp duty, property taxes etc. initiated by the Government are steps directed at making the real estate a promising investment option in India. As an outcome of the supportive Governmental policies, the foreign contributions to REFs in India have witnessed a steady rise of 40 to 45 per cent per year. The domestic financial institutions have also built up their investments in REFs like their foreign counterparts. This combined participation from both along with contributions of the corporate houses has accelerated the growth of REFs in India. Securities and Exchange Board of India (SEBI), the regulatory authority of securities market in India, has been trying to develop various innovative models for financing real estate market over the last few years.

SEBI's first attempt to bring in REITs in 2007 was not successful. So SEBI went ahead with its second attempt to bring in a REIT regime in the REMF format. But, this was also not very successful for want of adequate interest from the investors. SEBI approved the guidelines for the real estate mutual funds (REMFS) according to which all the schemes having an objective to invest directly or indirectly in real estate property will be governed by the provisions and guidelines under SEBI (Mutual Funds) regulations. SEBI made it clear that the structure of the REMFS, initially, would be close ended. The units of REMFS would be compulsorily listed on the stock exchanges, and NAV of the scheme would be declared daily. The scope of the REMFS was kept wide open, as the guidelines allow these schemes to invest in (i) directly in real estate properties within India, (ii) mortgage (housing lease) backed securities, (iii) equity shares/bonds/ debentures of listed/unlisted companies which deal in properties and undertake property development, and (iv) other securities.

According to SEBI guidelines, REMFs need to appoint a custodian who would grant the certificate of registration to carry on the business of custodian of securities by the Board. The custodian would keep safely the title of real estate properties held by the REMFs. Earlier, in the absence of REMFs, companies setting up REFs had to restrict themselves to financial institutions, corporate sector and high net worth individuals for creating their investor base. The REMFs were supposed to offer the real estate developers another source of funds, as the SEBI guidelines allow the funds to invest in the equity of public listed or privately held real estate developer companies as much as 65 per cent of the fund size.

The minimum investment norms stipulated in the SEBI guideline were thoughtfully designed to promote pure investment in the sector rather than speculation. SEBI guideline said that the REMF would invest at least 35 per cent of the assets in real estate properties that were already completed and usable. Under construction projects, vacant land or properties specified for agriculture use would not be considered as "real estate property" for satisfying the above 35 per cent norm. In addition, minimum 75 per cent investment was earmarked for real estate properties, mortgage-backed securities, equity or bonds or debentures of publicly listed or privately held companies dealing in real estate and in other securities. Here, the other securities would mean only debt and money market instruments. Clearly, SEBI wanted the REMFs to abstain from investing in under-construction projects or vacant land, as such investments were supposed to take a longer period to produce a decent yield and the retail investors were not often willing to wait for that long. In addition, such investments were perceived to have higher risks attached and gray areas about valuations. There were mixed views on the efficacy of REMFs in raising funds for the real estate sector and improving the liquidity of the players, and the impact of such developments on real estate prices. Anyway, the response from the investors towards REMFs was not as impressive as expected by SEBI. So, SEBI's second effort to bring in REFs in the form of REMFs was also not successful.

8. PROMOTION OF REITS: SEBI REGULATIONS 2014 AND REVISED REGULATIONS 2016

Failure of its first two attempts to improve liquidity in the real estate market made SEBI to float REFs in the form of REITs (Real Estate Investment Trusts) again, in its third attempt. As part of its third initiative, SEBI was successful in releasing the Draft of its Real Estate Investment Trust Regulations (Draft REIT Regulations) in 2013 and gathering the public comments on the above draft. SEBI did a commendable job in taking into account international models and views of stakeholders. It was envisaged that REITs should likely emerge as a preferred form of asset backed investment with established revenue streams. Also, it aimed at protecting the interests of investors seeking exposure in real estate as an asset class and also to infuse additional transparency and liquidity in the Indian real estate market. With Indian players showing an increased keenness to list Indian real asset listings offshore, especially in SGX, SEBI's move could attract them to such markets onshore and increase depth of Indian real estate capital markets. From a private equity in real estate perspective, REITs could create exit options for developers and financial investors allowing them to move completed assets to REIT and provide much needed liquidity in the market.

As envisaged, SEBI formally flagged off its final version of REIT Regulations in 2014. While developers and lenders welcomed the move, the investors were still not convinced. For developers REITs offered a convenient way to offload their commercial assets and also to reduce debts, while for lenders REITs reduced their business risk and expand their exposure to real estate business further. The poor turn out from the investors was a setback for the REIT Regulations 2014. Though the launch of REIT Regulations was a positive step forward on the part of SEBI, several issues concerning taxation, stamp duty and foreign participation remained. Thus, in spite of the various benefits as contemplated by SEBI, REITs did not take off as expected because specific tax exemptions are not provided. Besides, foreign investment in REITs also did not materialize as expected, because the amendments to the extant exchange control regulations were not carried out. Here, the investors were primarily put off by the governance risks in the asset class and the low liquidity of REIT investments compared to equities or bonds. Returns on REITs depend on the demand and rents for office space, they also compare poorly to other debt instruments during the economic slump. Table II gives the basic details regarding the REITs in their earlier form (REIT Regulations 2014) and the changes in the structure of REITs after effecting the relaxations contemplated by SEBI in June 2016 (SEBI Regulations 2016).

Table-II: Relaxations by SEBI on REIT Regulations 2014 in REIT Regulations 2016

Structure of REITs: REIT Regulations 2014	Relaxations by SEBI: REIT Regulations 2016
This is a step that makes more attractive for the investors. Only single-level Special Purpose Vehicle (SPV) is allowed in 2014 Regulations. Rules relating to related party transactions as per these regulations	The 2016 regulations propose to allow REITs to invest in property via multi-layered Special Purpose Vehicles (SPVs) rather than single-level SPVs as in REIT Regulations 2014. Besides, the 2016 regulations seek

are elaborate and hence cumbersome to comply with.	to rationalize the onerous rules regarding the related party transactions.
Only three sponsors are allowed as per the 2014 Regulations	The 2016 Regulations propose to allow upto 5 sponsors.
In under-construction projects investment upto 10 per cent alone is allowed	In under-construction projects investment upto 20 per cent alone is allowed

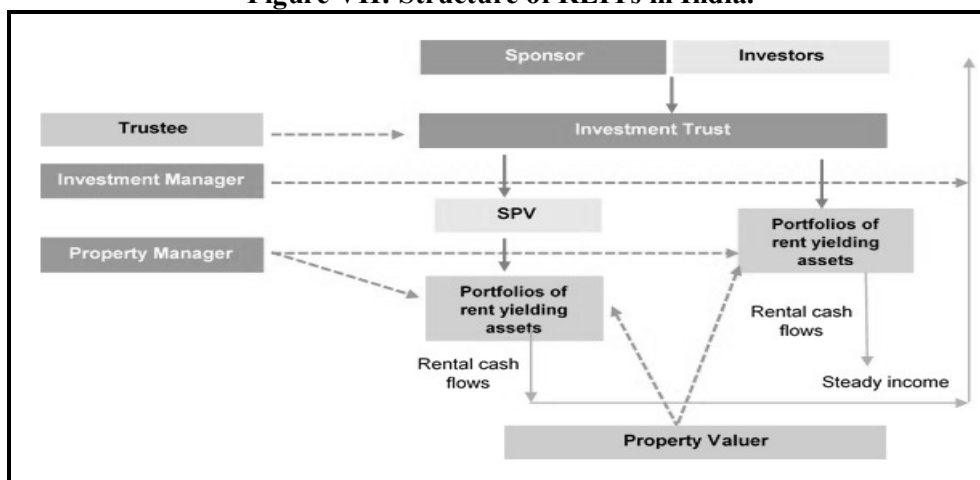
Sources: Compiled by the Authors, from sources like SEBI publications, press releases etc.

It may be noted that various relaxations as per the 2016 Regulations (Table II) would make life easier for the sponsors and managers of REITs. However, these may not out to be undesirable for investors. For instance, a multi-layered structure of SPVs may make it harder for the investors to discern the ultimate assets to held in their REIT portfolio. Allowing more sponsors into REIT may reduce the skin in the game for sponsors. The fact is that REITs can kick off operations based on property assets transferred by their sponsors. This creates conflict of interest between REIT sponsors and the ultimate investors in REITs. As per the 2014 regulations, this risk of investors was addressed by two means (i) elaborate related party rules, and (ii) skin in the game requirements in these regulations. Accordingly, the sponsors were required to invest at least 25 per cent of the outstanding corpus of a REIT for the first three years with a collective networth of at least Rs.100 Crore. As per the revised regulations (2016), as the number of sponsors could go up to 5 (as against 3 as per the 2014 regulations) resulting in dilution in controls, and risk of investors would go up accordingly. There was an attempt to safeguard the interest of the investors against the related party transactions, by stipulating unit-holder approvals and independent valuation reports for such related party transactions. But, the experience with such related party deals in listed companies in India so far shows that often disinterested investors simply favour such proposals resulting in the interests of affected investors getting not protected. The investors’ interests are not properly safeguarded by the provisions of related party transactions.

9. REITS IN THE NEW REGIME, THE FIRST REIT ISSUE, AND STRUCTURE OF REITS IN INDIA

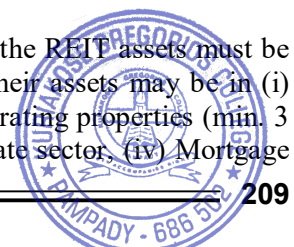
The developers who are in the possession of a portfolio of rent generating assets traditionally prefer mobilizing extra funds through debt by way of lease rental discounting (LRD). Of late, a few very reputed developers have raised funds by issuing Commercial mortgage-backed securities (CMBS). But, the attractiveness of CMBS is dependent on the outlook on interest rates and may not be liked by developers in a situation of falling interest rates, as is the prevailing case of India. From the ownership viewpoint, while LRD and CMBS continue to retain developer’s holding in the projects, REIT offers partial exit to developer creating a monetizing opportunity. The first REIT in India (viz. Embassy Office Parks REIT) is in fact a joint venture between Blackstone and Embassy Group. This REIT issue was open in Indian stock market on April 1, 2019. Issue got oversubscribed on the last day of the issue. Embassy’s portfolio consists of seven office parks and four city-centre office buildings totaling 32.6 million square feet (msf) as of March 31, 2018, in cities including Bengaluru, Pune, Mumbai and Noida. The current structure of REITs in India is as given in Figure VII.

Figure VII: Structure of REITs in India.



Source: CRISIL Research (2019)

Regarding the assets of REITs, there is a condition that at least 80 percent of value of the REIT assets must be in completed and rent generating properties. However, not more than 20 percent of their assets may be in (i) Under-construction properties (min. 3 years holding), (ii) Completed and not rent generating properties (min. 3 years holding), (iii) Listed or unlisted debt of companies or body corporate in real estate sector, (iv) Mortgage



backed securities (MBS), (v) Equity shares of listed Indian companies which derive at least 75 percent of their operating income from real estate activity, (vi) Government securities, and (v) Money market instruments or cash equivalents.

10. REITS FOR THE REVIVAL OF RESIDENTIAL REAL ESTATE SECTOR IN INDIA: SOME STRATEGIES

The excellent response received for the first REIT gives hopes to the developers for more REIT issues, as they get an option to raise funds and reduce their debt. Some suggestions for promotion of REITs for faster growth of residential real estate sector in India are as follows:

- (i) In general, commercial real estate projects of developers are interested in REITs. While the fact is that most developers have both commercial and residential portfolios and hence funds raised from commercial (non-residential) assets would also help their residential projects, it is advisable that Government should encourage developers to use their residential assets for REIT issues. This will have a direct positive impact on residential projects of developers. Special tax incentives be offered for such REITs.
- (ii) Given the fact that not even one-third of the total residential housing units developed by the major developers qualify for the 'Affordable Housing' tag (which are eligible for various incentives offered by the Government), focused attention is required on the developers of 'Affordable Housing' or 'Budget Housing' projects (say, not less than 50 percent of the total housing units developed) and such developers be selectively granted special concessions and relaxations on tax, permits etc. This is because 'Housing for All by 2022' is a governmental commitment.
- (iii) Besides, incentives and concessions to the developers of Affordable Housing units, financiers to such units like banks and housing finance companies (HFCs) should also be granted similar incentives, like, Priority sector status to such advances etc.
- (iv) Promotion of private equity (PE) funds that invest in real estate sector (particularly residential real estate) is advisable. In calendar year (CY) 2018 the PE funding in the commercial segment had touched a four year high. PE funding in residential real estate should be encouraged by extending them special incentives, given the national goal of 'Housing for All by 2022'.

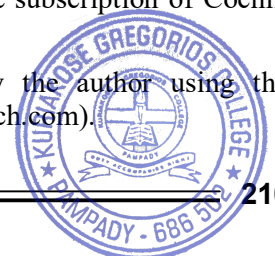
10. CONCLUDING REMARKS

Because liquidity crunch is a problem for the real estate industry and also the financiers to this industry (like, the NBFCs including HFCs) the demand is yet to pick up momentum. It is expected that developers with both commercial and retail portfolios will be in a better position to sustain compared to other developers. With the regulatory framework for real estate sector in India witnessing substantial developments in the last few years, developers and PE funds (both domestic and foreign) have been rationalizing their commercial and retail portfolios since 2012. This is evident from the PE investments in such real estate properties.

At present, the top six cities (viz. Bengaluru, NCR, MMR, Pune, Chennai, and Hyderabad) are estimated to possess a total inventory of nearly 460-470 mn sq ft (A grade) commercial properties. Not less than 20 percent of the above estimated properties can be used for raising funds through the REIT route, considering the factors such as project locations, developers' brands, ownership of key real estate funds, quality of tenants present, tenure of lease agreements, and so on). Obviously, if REITs emerge from the above REIT-able properties then that itself would provide the requisite level of growth momentum to the real estate sector in India, and this in turn translates into growth of other sectors of the economy given the vast linkages of the real estate sector with nearly 300 allied sectors. Let us hope for the best.

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Contents lists available at ScienceDirect

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First principle study of Lead free halide double perovskites $\text{Cs}_2\text{AuBiX}_6$ (X = Cl, Br)

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ARTICLE INFO

Article history:

Received 6 September 2019

Received in revised form 2 December 2019

Accepted 4 December 2019

Available online xxx

Keywords:

Halide double perovskites

Perovskite solar cells

Optoelectronic applications

Band gap

Toxicity

ABSTRACT

Halide double perovskites based on bismuth and silver have recently been studied extensively as potential environment friendly alternatives to lead-based hybrid halide perovskites. In this paper the structural, electronic and optical properties of Pb-free halide double perovskites $\text{Cs}_2\text{AuBiX}_6$ were investigated. The material was systematically analyzed within the framework of Density Functional Theory (DFT) using various exchange correlation such as LDA, PBE and PBE-sol. The optimized lattice parameters are found to be 10.94 Å and 11.45 Å for Cl and Br respectively in the face-centered cubic structure ($Fm\bar{3}m$ space group). It is found that these compounds have an indirect band gap. As the halogens are changed from Chlorine to Bromine the band gap is decreasing and first-principles calculations indicate that the energy gaps values are 0.63 eV and 0.24 eV respectively. This energy might be slightly underestimated as expected from DFT calculations. Optical studies make it clear that the compound shows good absorbance in visible region. The optical properties of $\text{Cs}_2\text{AuBiX}_6$ is comparable to hybrid halide perovskites MAPbI_3 and halide double perovskites (like $\text{Cs}_2\text{AgBiBr}_6$) making it a suitable candidate for absorber layer in perovskite solar cells.

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1. Introduction

Investigations in solar cell photo voltaic have been growing exponentially with astounding success rate over the past ten years ever since the inception of MAPbI_3 as a dye in the dye sensitized solar cells by Kojima, et al. in 2009 [1]. The Power Conversion Efficiency (PCE) is increasing in an exponential rate and reached a remarkable level of above 22% in a very short span of time [2]. Various kinds of materials were explored for enhanced PCE, improved stability, reduced cost and being environment friendly. Solar cells' realizations based on hybrid halide perovskites are found to be one of the most promising photovoltaic technologies, owing to their excellent absorption in the visible region [1,3–5], optimal diffusion length for the photo-generated excitons [6–8] enhanced carrier mobility and lifetime [9], and capability in recycling of the carriers macroscopically [10,11].

MAPbI_3 (MA = CH_3NH_3) is considered as the archetype of perovskite light harvester and it satisfies the properties a light harvester could have needed [12–15]. In fact, the presence of this material itself ensures efficiency of the solar cell, regardless of the device design. It is a well-established fact that the astonishing PCE exhibited by the solar cells is due to the magnificent characteristics of lead (Pb) as it favors the reasonable charge mobility, optimal diffusion length, strong optical absorption and a suitable band gap, in forming an organo-halide perovskite structure. But there are two main challenges that need to be addressed in order to use these perovskite solar cells for electricity production [16]. One is the compound stability, as they disintegrate when exposed to light, moisture, oxygen and UV radiations [17] and other is the toxicity of lead [18]. To implement Pb replacement, several lead-free perovskites and perovskite-derivatives have been proposed during the past two, three years as potential substitutes [19]. One such promising category is the halide double perovskites having the structure $\text{AB}'\text{X}_6$ based on alternating corner-shared BX_6 and $\text{B}'\text{X}_6$ octahedra (where B = Ag, Au, Cu; B' = Bi, Sb). But one of the main disadvantage of this category is the indirect and wide

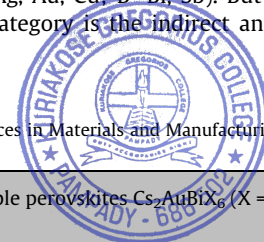
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<https://doi.org/10.1016/j.matpr.2019.12.022>

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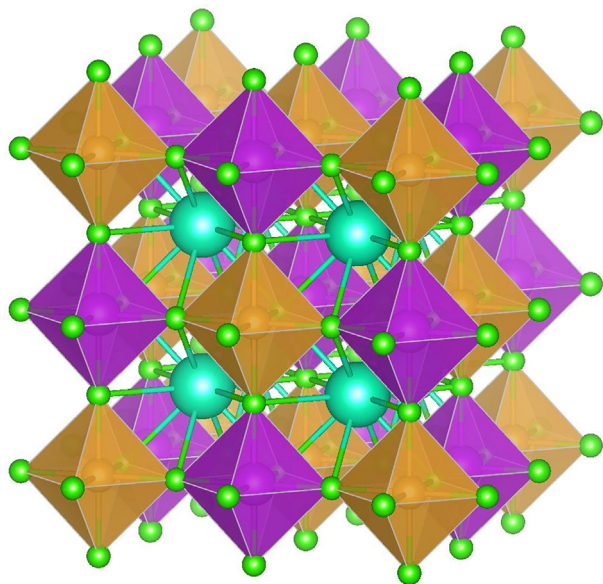


Fig. 1. Optimised crystal structure of the halide double perovskite $\text{Cs}_2\text{AuBiBr}_6$. Here brown/purple/green/turquoise sphere represents Au/Bi/Br/Cs atom. Au and Bi centered octahedra are shown as brown and purple polyhedral, respectively. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

band gaps of over 2 eV [20–22]. To overcome this, computational and experimental studies are focusing on the proper material designing and band gap engineering.

In the present work investigation is carried out to envisage $\text{Cs}_2\text{AuBiX}_6$ as a promising environment friendly, stable alternative to lead-halide perovskites. We studied the structural and optoelectronic properties using first-principles Density Functional Theory (DFT) and found that as X changes from Cl to Br the band gap is decreasing. The lattice parameters are 10.94 Å and 11.45 Å for X as Cl and Br respectively, using PBE functional. These values are in good agreement with the reported values, 10.94 Å and 11.42 Å respectively [23]. The energy gaps are found to be 0.65 eV and 0.25 eV as the halides go from Chlorine to Bromine. The reported values are 1.38 eV and 1.6 eV [23] and 1.1 eV and 0.14 eV [24]. In fact, in its metallic form, Au is the best known electrical conductors, owing to their filled d shell and the free-electron-like behavior of the s shell. In addition, in an octahedral environment, the ionic radius of Au^+ (1.37 Å) is comparable to those of Pb^{2+} (1.19 Å) and Bi^{3+} (1.03 Å) [25].

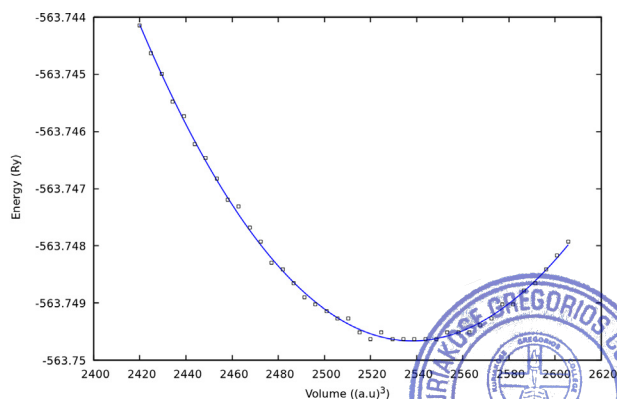
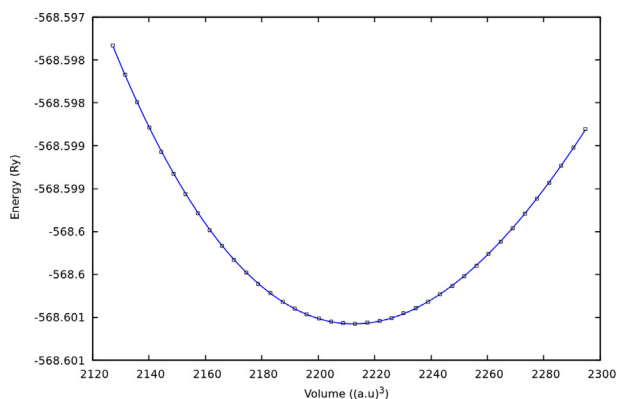


Fig. 2. The total energy per unit cell as a function of the cell volume for $\text{Cs}_2\text{AuBiX}_6$ (X = Cl, Br).

2. Computational details and results

In the present study, the calculations were carried out using the pseudo potential plane-wave method as implemented in Quantum ESPRESSO package [26] (version 6.3). The ultra-soft pseudo potentials were generated using the atomic code provided in the package. The plane-wave cutoff energy of 60 Ry and k-point mesh of $(8 \times 8 \times 8)$ for structural optimization guaranteed a total energy convergence of 1 meV per unit cell.

For the electron core exchange correlation interaction, the Perdew-Burke-Ernzerhof functional (PBE) [26] within generalized gradient approximation (GGA) was used. In addition Local Density Approximation (LDA) method and Perdew Burke Ernzerhof parameterization of the generalized gradient approximation for solid (PBE-sol) were adopted to treat the exchange correlation interactions. The equilibrium lattice constants are obtained by calculating the total energies at different unit cell volumes and then fitting the obtained E - V data into the Birch- Murnaghan equation of states [27]. Sampling of Brillouin zone integration with Monkhorst-Pack k-point mesh $8 \times 8 \times 8$ was set. For better calculations of the electronic and optical properties, we used a denser k-point mesh of $(12 \times 12 \times 12)$. The crystalline phases were supposed to be $\text{Fm}\bar{3}\text{m}$ space group. The convergence threshold for self-consistent-field iteration was set at 10^{-7} eV and the structures were fully relaxed using BFGS quasi-newton algorithm and the atomic positions were fully optimized.

2.1. Crystal morphology

The double perovskite structure of $\text{Cs}_2\text{AuBiX}_6$ is shown in Fig. 1. The structure is similar to the ABX_3 perovskite structure, composed of a 3D network of corner connected octahedra, with Cs^+ ions in the center of the cub-octahedron interstices. The halide double perovskite structure is built of alternating Au^+ and Bi^{3+} centered octahedra, with each Au/ Bi atom coordinating with six X-atoms (four in equatorial and two in apical direction). This builds up a superstructure that is typically referred to as rock salt ordering.

Table 1

Calculated lattice constants a (Å), estimated within the LDA, PBE and PBE-sol approximations of DFT.

X		Cl	Br
a(Å)	LDA	10.52	11.03
	PBE	10.94	11.45
	PBEsol	10.69	11.27
a(Å) [23]	PBE + SOC	10.94	11.42

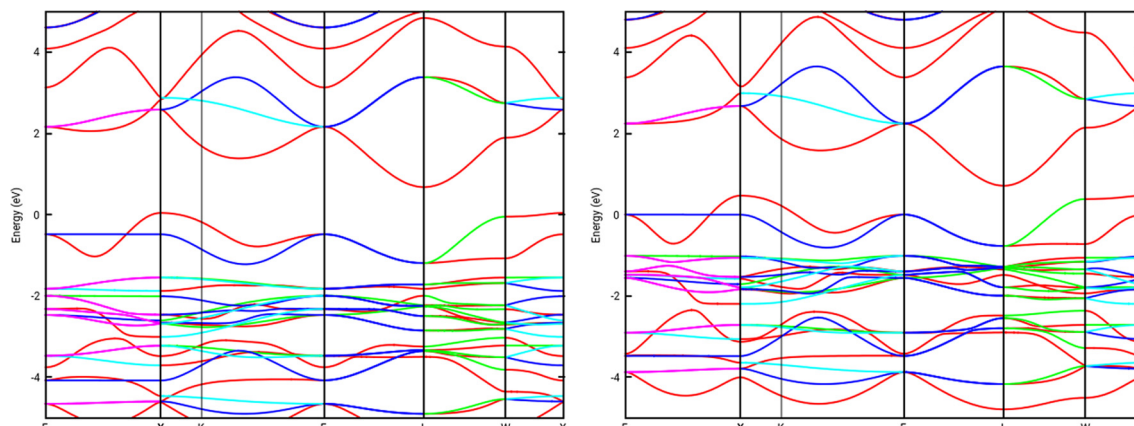


Fig. 3. DFT functional calculations revealing the band structure diagrams for $\text{Cs}_2\text{AuBiX}_6$ ($X = \text{Cl}$ and Br) calculated with DFT-PBE, along high symmetry points in Brillouin zone.

Table 2

Bandgap energies of $\text{Cs}_2\text{AuBiX}_6$ at different symmetry points compared with other theoretical results; calculated with different exchange correlation functional.

X	PBE	PBEsol	Reference (HSE)
Cl	0.63	0.44	1.38 [23] 1.6 [24]
Br	0.24	0.09	0.84 [23] 1.1 [24]

The calculated lattice constants from Self Consistent Field (SCF) cycles for $\text{Cs}_2\text{AuBiX}_6$ is 10.94 Å and 11.45 Å for $X = \text{Cl}$ and Br respectively. The optimized crystal structure of the compound is shown in Fig. 1. The volume optimization is performed using the Birch-Murnaghan's equation of state, in which the total energy of the unit cell is minimized with respect to the cell volume. Fig. 2 shows the total energy as a function of the cell volume for both $\text{Cs}_2\text{AuBiX}_6$ ($X = \text{Cl}, \text{Br}$). In volume optimization process ground state energy and minimum volume shows the compound stability. It is concluded from the optimizations that $\text{Cs}_2\text{AuBiX}_6$ remain in stable cubic phase. In Table 1 the calculated values of lattice constants are compared with previously reported values.

2.2. Electronic and optical properties

Band structure calculations were performed within LDA PBE and PBE-sol approximations to investigate the electronic structure

properties of the $\text{Cs}_2\text{AuBiX}_6$ compounds. It is found that the band gap of $\text{Cs}_2\text{AuBiBr}_6$ is less than that of $\text{Cs}_2\text{AuBiCl}_6$. This general trend is attributed to the increase in size of the halogen atom [20–24]. It is well-known that there is a strong dependence of the band gap upon the lattice parameters and electronegativity. The energy gaps are found to be 0.63 eV and 0.24 eV for chloride and bromide respectively. Iodides are reportedly unstable [23]. The energy gap values obtained are slightly low when compared to earlier reported values. But it is not surprising as DFT often underestimate the energy gap values. The band structures of $\text{Cs}_2\text{AuBiX}_6$ are shown in Fig. 3.

The electronic band structures of $\text{Cs}_2\text{AuBiX}_6$ at high symmetry points in the Brillouin zone were analyzed. It has indirect band gap with valence band maximum (VBM) at $X(0, 2\pi/a, 0)$ and the conduction band minimum (CBM) at $L(\pi/a, \pi/a, \pi/a)$. The compound is viable for band gap engineering for photo-voltaic applications. The obtained band gaps are within the accuracy limits of DFT. Available reported values are compared. Calculated band gaps and previously reported values are presented in Table 2.

The analysis of total DOS reveals that the exchange correlation functional have insignificant effects on the main characteristics of peaks even though their impact is significantly observed on energy bandgap values. Further the analysis provides an insight about bandgap engineering measures. Total Dos plots using PBE functional is shown in Fig. 4.

The linear absorption spectrum and refractive index as a function of energy for $\text{Cs}_2\text{AuBiX}_6$ ($X = \text{Cl}, \text{Br}$ & I) are shown in the Fig. 5. The investigated compound shows good absorption in visible region. From the spectrum it is clear that as we move from

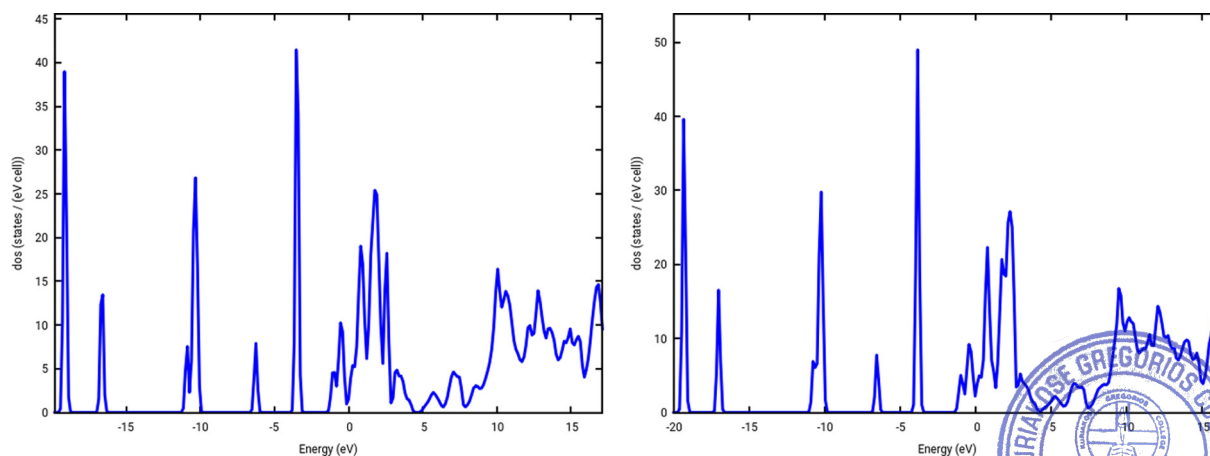


Fig. 4. Total density of states (TDOS) of $\text{Cs}_2\text{AuBiCl}_6$ and $\text{Cs}_2\text{AuBiBr}_6$.

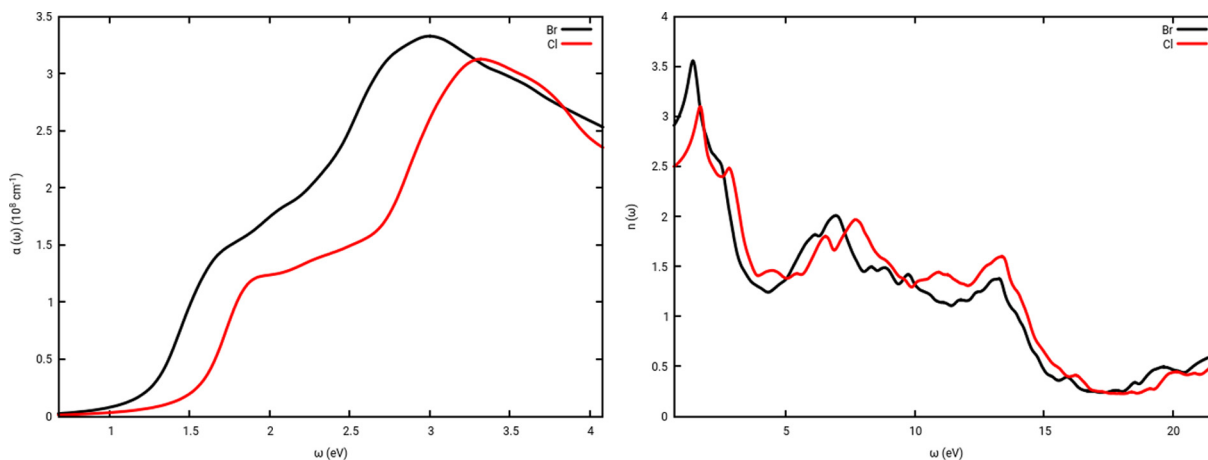


Fig. 5. Calculated photon absorption spectra and refractive index of $\text{Cs}_2\text{AuBiBr}_6$, and $\text{Cs}_2\text{AuBiCl}_6$.

Chlorine to Bromine, in the visible region, the peaks are red shifted. The system investigated is analogous to the well-studied $\text{Cs}_2\text{AgBiX}_6$ [28].

3. Conclusion

First principle calculations were employed to study the stability and opto-electronic properties of $\text{Cs}_2\text{AuBiX}_6$ which is analogous to the well-studied $\text{Cs}_2\text{AgBiX}_6$. Briefly, from the structural studies we conclude that $\text{Cs}_2\text{AuBiX}_6$, where X is either bromine or chlorine are stable and can be considered as a potential candidate for PV applications. The studies on electronic properties revealed an indirect band gap, with the valence band maximum at X, and the conduction band minimum at L points of the Brillouin zone. Even though the band gap is indirect; the DOS plots clearly indicate that proper band gap tuning mechanism can be employed for making the compound suitable for applications in solar cells. The calculated band gaps for $\text{Cs}_2\text{AuBiCl}_6$ and $\text{Cs}_2\text{AuBiBr}_6$ are 0.63 eV and 0.24 eV respectively in PBE-GGA approximations. It is concluded that, as the halide ion changes from Cl to Br in $\text{Cs}_2\text{AuBiX}_6$, lattice constant is increasing. Dielectric properties showed reveal an increase in dielectric constant as we move from chlorine to bromine. Optical studies specify that these materials can harvest the visible and ultraviolet energy ranges.

CRedit authorship contribution statement

Nishitha P. Mathew: Data curation, Writing - original draft, Writing - review & editing. **Rajeev Kumar:** Methodology, Software. **R. Radhakrishnan:** Conceptualization, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We would like to acknowledge PARAM Yuva supercomputing facility at Centre for Development of Advanced Computing (C-DAC), Pune, India for providing the wonderful computing facility. Gnu plot and VESTA are used in the manuscript.

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First principle study of the structural and optoelectronic properties of direct bandgap double perovskite Cs₂AgInCl₆

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ARTICLE INFO

Article history:

Received 7 November 2019

Accepted 17 March 2020

Available online 22 April 2020

Keywords:

Double perovskites

DFT

Light absorber

Direct bandgap

ABSTRACT

Solar cells incorporating double perovskites as absorber layer are currently showing very remarkable progress as a potential environment friendly substitute for lead based hybrid halide perovskites. In the present work we tried to investigate the structural and opto-electronic properties of lead (Pb) free halide double perovskite Cs₂AgInCl₆. Density Functional Theory (DFT) is employed to systematically analyze the material. For the electron core exchange correlation interaction, the Perdew-Burke-Ernzerhof functional (PBE) within generalized gradient approximation (GGA) was used. The interactions were also analyzed using Local Density Approximation (LDA) method and Perdew Burke Ernzerhof parameterization of the generalized gradient approximation for solid (PBE-sol). The optimized lattice parameters are obtained as 10.565 Å for the material in face-centered cubic structure (Fm-3 m space group). The optimized density is found to be 3.93 gcm⁻³. The first-principles calculations have given the energy gaps values as 1.1 eV. This energy is slightly lower as an energy underestimation is expected in DFT based calculations. A remarkable factor to mention is the direct bandgap exhibited by the material at $\Gamma(\pi/a, \pi/a, \pi/a)$, unlike other double perovskites. It is clear from optical studies that the compound is a good absorber in visible region. The optical properties of Cs₂AgInCl₆ are comparable to hybrid halide perovskites MAPbI₃ and halide double perovskites (like Cs₂AgBiCl₆). Through proper composition grading this material can be envisaged as a possible absorber layer in solar cells.

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Selection and peer-review under responsibility of the scientific committee of the International Conference on Photochemistry and Sustainable Energy (ICPSE 2019).

1. Introduction

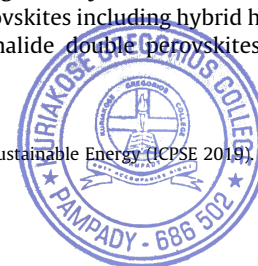
Perovskite solar cells (PSCs) constitute a new emerging low cost solar cell technology that ignited the minds of photovoltaic community due to their remarkable growth in photon conversion efficiency (PCE) which is reported as from 3.8% to 25.2% [1,2] over a decades time. The characteristic properties of perovskite materials are preferable charge diffusion length, direct bandgap, tunable bandgap, low carrier recombination, high carrier mobility, molar extinction coefficient and absorption [1–7] in the visible spectrum. Most investigated group of Perovskite solar cells belong to the lead based Hybrid Organic Inorganic halide Perovskite having the form APbX₃, where A is MethylAmmonium or Formamidinium and X is Cl, Br or I. Even though the efficiency of these materials improved persistently, two main challenges remained to be addressed in

order to commercialize perovskite solar cells for photovoltaic applications; the compound stability and the toxicity of lead [8–10].

Different structural design principles were adopted in search of potential Pb-substitution. The very first natural attempt was to replace Pb²⁺ by Sn²⁺ from the same periodic group, but the chemical instability of Sn²⁺ and poor performance give rise to limitations for their further use. Numerous efforts were focused on exploring the isoelectronic systems through rational designing to replace Lead with other non-toxic metals such as Bismuth, Germanium, and Antimony [11]. For attaining stability, substitution of A site with different isovalent species was attempted but that resulted in the decreased efficiency [12,13]. Theoretical screening of the compounds where Pb was replaced by other isovalent elements reveals that in most cases this resulted in non-ideal band gaps [14,15]. Various other attempts using vacancy ordered double perovskites, cation ordered double perovskites including hybrid halide double perovskites, all inorganic halide double perovskites and

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two-dimensional perovskites also have been reported [16]. For instance, it has been shown that by employing mixed-halide and mixed cation perovskites one can tune the electronic properties [17–20], as well as the composition of the mixes can be explored for stability [21]. But materials that can rival the unique optoelectronic properties [14,22] of lead-halide perovskites have not been found yet. Although stable and non-toxic $AB'B''X_6$ double-perovskites with alternating corner shared BX_6 and $B''X_6$ octahedra (where $B = Ag, Cu$; $B' = Bi, Sb, In$) are possible, they have indirect and wide band gaps of over 2 eV. [14,23,24].

Among the inspected huge number of compounds, Pb-free halide double perovskites, those based on In and Ag were more explored recently as they were found to have direct band gap. Various methods of band gap designing of $Cs_2AgInCl_6$ were reported [25–27]. Volonakis et al. successfully synthesized $Cs_2AgInCl_6$ and reported a measured band gap of 3.3 eV, and the compound was photosensitive and turns reversibly from white to orange under ultraviolet illumination. They performed an empirical analysis of the stability of Cs_2InAgX_6 and their mixed halides based on Goldschmidt's rules, and reported the possibility to form $Cs_2InAg(Cl_{1-x}Br_x)_6$ for $x < 1$ [25]. By alloying sodium cation into $Cs_2AgInCl_6$ Luo et al. reported an efficient and stable white-light emitting lead-free double perovskite, whose PL efficiency was increased three times compared to pure $Cs_2AgInCl_6$. They reported that an optimally alloyed $Cs_2(Ag_{0.60}Na_{0.40})InCl_6$ with 0.04 per cent bismuth doping emitted warm-white light with 86 ± 5 per cent quantum efficiency and works for over 1000 h [28]. Formation energy -9 meV/atom, band gap using DFT 0.93 eV and carrier effective masses 0.5me for holes and 0.28me for electrons respectively were reported by Jain et al. [29]. Lee et al. synthesized $Cs_2AgInCl_6$ nano crystals which exhibited superior stability and showed discrete optical properties such as multiple absorbing states that resolved the parity forbidden band edge transition at 3.33 eV and higher order parity allowed transition at 4.88 eV and multiple emission states at 350 nm and at 395 nm [30]. Liu et al. recently reported the synthesis of undoped and Bi-doped $Cs_2AgInCl_6$ Nano Crystals (NCs). They observed a boosted Photo Luminescence Quantum Yield (PLQY) of 11.4 through adding traces of Bi and the broadband orange emission peaking at 580 nm [31].

In the present work we investigated, using DFT, to envisage $Cs_2AgInCl_6$ as a promising environment friendly, stable alternative to lead halide perovskites. We studied the structural, electronic and optical properties using first-principles density functional theory. Being an absorber with direct band gap and having good optical absorption it might be a strong candidate for potential applications in opto-electronics and photovoltaic.

2. Computational details and results

For the current work, computations have been carried out using the Quantum-Espresso suite [32]. $Cs_2AgInCl_6$ in the face centred cubic (Fm-3 m) structure is optimized theoretically via total energy minimization. The generalized gradient approximation formulated by Perdew, Burke, and Ernzerhof (PBE) is used as exchange correlation functional [33]. The convergence test for kinetic energy cut-off for wave function and charge densities were set on 90 and 720 Ry, respectively. Structure optimization and the K-point meshes for different structures were generated according to the Monkhorst–Pack scheme for the Brillouin zones. Sampling of Brillouin zone integration with k-point mesh $8 \times 8 \times 8$ was set, while denser k-mesh of $16 \times 16 \times 16$ was used for DOS and optical calculations [34]. In Table 1, the lattice parameters of $Cs_2AgInCl_6$; currently obtained based on structure optimization with PBE exchange functional and previously reported values are tabulated.

Table 1

Calculated lattice constants a (Å) and bandgap energy of $Cs_2AgInCl_6$ compared with other theoretical and experimental results.

a (Å)	10.565
reported a (Å)	10.4805 [35], 10.467 [36]
Bandgap E_g (eV)	1.1
reported E_g (eV)	3.3/2.7 \pm 0.6 [25] 0.93 [29] 3.23/3.33 [37], 3.22 [38]

2.1. Structural studies

The investigated material possesses a face-centered cubic structure belonging to the space group Fm-3 m and with a lattice parameter of 10.565 Å. The Laue class is Oh(m 3 m). The structure is similar to the typical rocksalt ordering of perovskite compounds, composed of a 3D network of corner connected octahedra, with Cs^+ ions in the interstices. The halide double perovskite structure is composed of alternating Ag and In centered octahedra of $B''X_6$ and $B''X_6$ in a 3D framework. The conventional structure of Cs_2AgInX_6 given in Fig. 1. The calculated lattice constants from Self Consistent Field (SCF) for $Cs_2AgInCl_6$ is 10.565 Å. Minimum volume (V_0) and the ground state energy (E_0) of unit cell are studied for investigating structural stability through volume optimizations. Optimization curve is shown in Fig. 2. The volume optimization is performed using the Birch-Murnaghan's equation of state. In volume optimization process ground state energy and minimum volume shows the compound stability. We concluded from our optimizations that $Cs_2AgInCl_6$ remain in stable cubic phase. Values of lattice constant and density are reported in Table 1.

2.2. Electronic properties

Band structure calculations were performed within PBE, LDA and PBEsol approximations to investigate the electronic structure properties of the $Cs_2AgInCl_6$ compound. Of these, calculations employed PBE show good results and a bandgap of 1.1 eV is obtained. It is well known that the bandgap is inversely proportional to the square of lattice parameters which in turn depends on electronegativity. In fact, valency of atoms at the B/B' sites controls the electronic structure. Total density of states is also studied and shown in Fig. 3. The band structures of $Cs_2AgInCl_6$ through

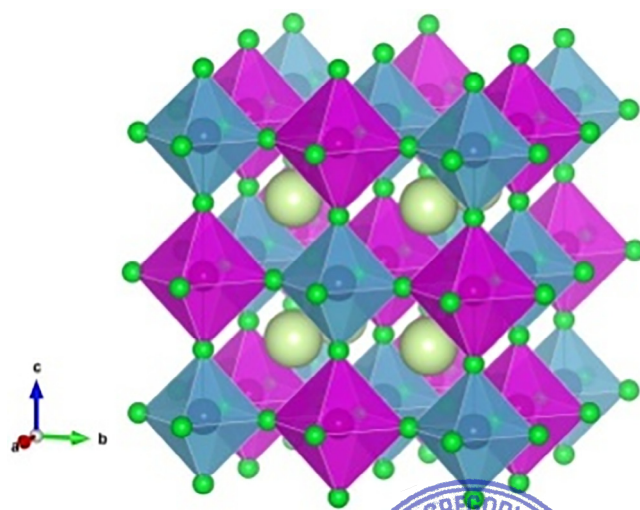
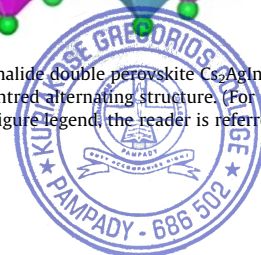
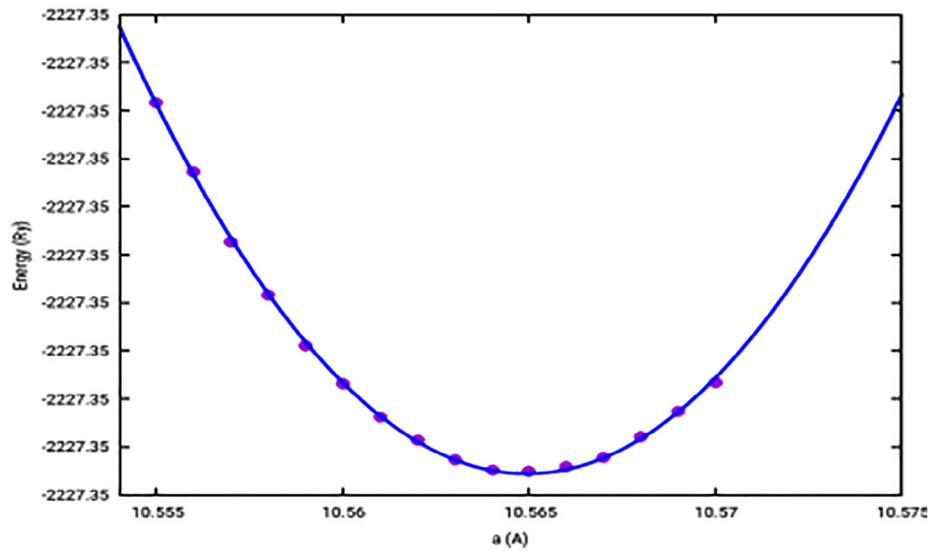
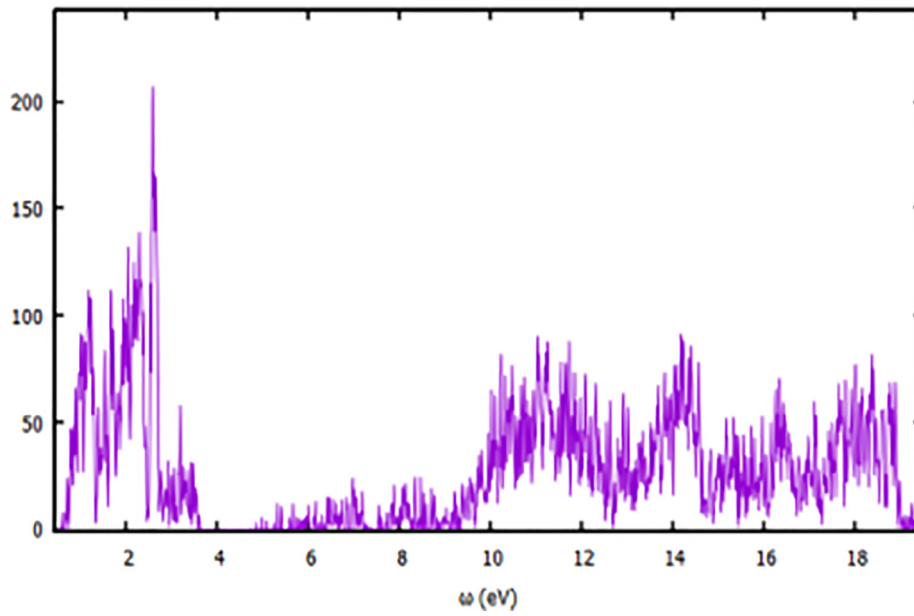
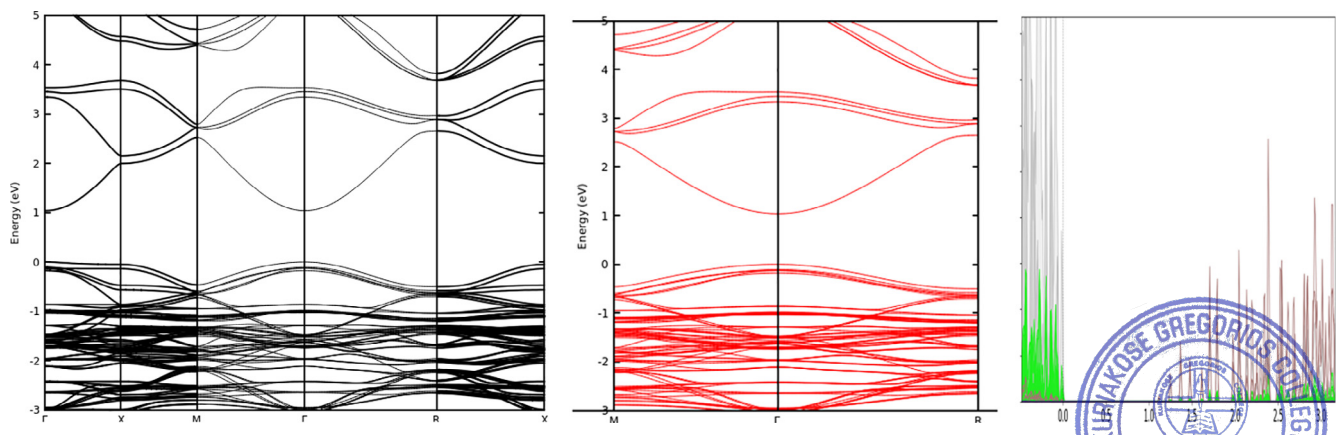


Fig. 1. Optimised crystal structure of the halide double perovskite $Cs_2AgInCl_6$. Here blue/purple octahedra represent Ag/In centred alternating structure. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)



Fig. 2. Optimization Curve for Cs₂AgInCl₆.Fig. 3. Total density of states of Cs₂AgInCl₆.Fig. 4. Electronic band structure of Cs₂AgInCl₆ along high symmetry points and Projected density of states.

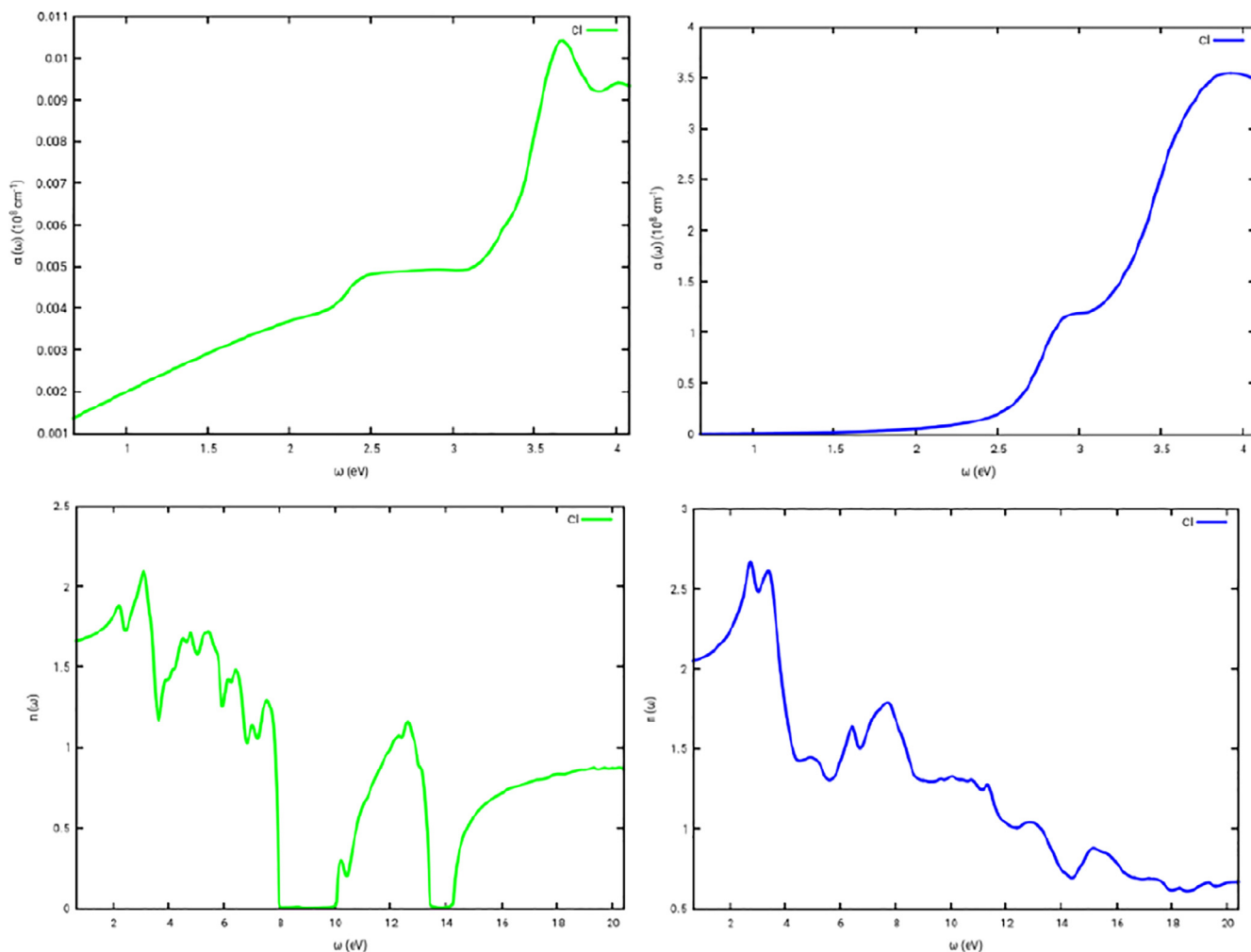


Fig. 5. Absorption and refractive index for the compound, as a function of photon energy. Figure on right (blue) is the absorption and refractive index plot for $\text{Cs}_2\text{AgBiCl}_6$. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

high symmetry points are shown in Fig. 4. The calculated band gap is found to be direct, with the valence band maximum (VBM) and the conduction band minimum (CBM) at $\Gamma(\pi/a, \pi/a, \pi/a)$ points of the Brillouin zone. Band gap for $\text{Cs}_2\text{AgInCl}_6$ is obtained as 1.1 eV. The obtained band gaps might be within the accuracy limits of DFT. Available reported values are given for comparison. Reported band gaps energy values are 0.93, 3.33, 2.76 0.6, 3.22 eV from theoretical calculations and 3.23 and 3.3 eV from the experiments. Calculated and reported bandgap energies are also tabulated in Table 1.

2.3. Optical properties

Structural and electronic properties studied reveal that the compound is suitable for photovoltaic applications. For optical studies the frequency dependent permittivity can be written as $\epsilon(\omega) = \epsilon_R + i\epsilon_I$, where $\epsilon_R(\omega)$ and $\epsilon_I(\omega)$ are the real and imaginary parts of the dielectric constant respectively. The refractive index n as a function of frequency expressed in terms of ϵ as

$$n(\omega) = \frac{1}{\sqrt{2}} \left(\sqrt{\epsilon_R(\omega)^2 + \epsilon_I(\omega)^2} + \epsilon_R(\omega) \right)^{\frac{1}{2}}$$

and the extinction coefficient $k(\omega)$ as

$$k(\omega) = \frac{1}{\sqrt{2}} \left(\sqrt{\epsilon_R(\omega)^2 + \epsilon_I(\omega)^2} - \epsilon_R(\omega) \right)^{\frac{1}{2}}$$

The complex dielectric function describes the electrical response of a material to the external electromagnetic fields; the imaginary part is directly related to the band structure of the material and describes its absorption behavior. We have the absorption coefficient in terms of ω as $\alpha(\omega) = \omega/cn(\omega)$ and $\epsilon_I(\omega) = 2\omega k(\omega)/c$ where c is the speed of light.

Refractive index and the absorption coefficient as a function of light energy for $\text{Cs}_2\text{AgInCl}_6$ are shown in the Fig. 5. From the absorption spectra it can be shown that the material has a good absorption in the visible region. So this compound can be used as a light harvester in u-v visible region. Absorption and refractive index plot for $\text{Cs}_2\text{AgBiCl}_6$ are also shown for comparison [39].

3. Conclusion

Briefly, from the structural studies we conclude that $\text{Cs}_2\text{AgInCl}_6$ is a stable compound thereby making it a potential candidate for PV applications. It is also reported that $\text{Cs}_2\text{AgInCl}_6$ perovskite has a high decomposition temperature and is stable upon prolonged exposure to air and moisture, which emphasize its potential in the field of photovoltaic absorbers and optoelectronic applications. The studies on electronic properties revealed a direct band gap, with the valence band maximum and the conduction band minimum at Γ point of the Brillouin zone, but the transitions are Laporte forbidden. Through proper composition grading suitable band gap can be achieved for making the compound appropriate

for applications in solar cells. From the optical studies it is clear that these materials can be helpful in the visible and ultraviolet energy ranges.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We would like to acknowledge PARAM Yuva supercomputing facility at Centre for Development of Advanced Computing (C-DAC), Pune, India for providing the magnificent computing facility. Gnu plot and VESTA are used in the manuscript.

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Electrospinning technique for the fabrication of poly(styrene-co-methyl methacrylate) nanofibers and the effect of fiber diameter on UV–Visible absorption and thermal properties

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ARTICLE INFO

Article history:

Received 8 November 2019

Received in revised form 31 December 2019

Accepted 30 January 2020

Available online 4 March 2020

Keywords:

Nanofiber

Electrospinning

Poly(styrene-co-methylmethacrylate)

Fiber diameter

Non woven fiber mat

Electrospinning

ABSTRACT

Nanofibers are gaining much importance in research field owing to its versatile applications and unique properties. Eventhough different methods are there to fabricate nanofibers; electrospinning is of great interest due to its added advantages in terms of cost effectiveness and wide applicability. Among different materials electrospun polymers are more preferred because of no post-processing requisites. The major challenge associated with electrospinning is to optimize the parameters determining the fineness of surface morphology of electrospun fibers. In the present study an attempt is made to investigate the effect of solution parameters such as concentration of the polymer solution, nature and ratio of solvent type and the processing parameters like applied voltage on the fineness of fiber surface morphology of copolymer poly(styrene-co-methyl methacrylate) fibers. The effect of fiber diameter on thermal degradation is monitored. The concentration studies were done by varying the concentration from 3% (w/v) to 20% (w/v) and for solvent studies varying proportions of THF and DMF were chosen. Voltage studies were carried out by varying the applied voltage from 15 kV to 25 kV. The characterization techniques include SEM, TGA UV–Visible Spectroscopy and FTIR analyses. The results showed that by adjusting the applied voltage, concentration of the polymer and solvent ratio, a good control over the fineness of surface morphology can be accomplished. From the TGA analysis it is found the degradation property of nanofibers varied as a function of fiber diameter.

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Selection and peer-review under responsibility of the scientific committee of the 2nd International conference on Advanced Materials – Materials for a Better Living.

1. Introduction

With the emergence of nanotechnology and nanomaterials the researchers are exploiting the potential of miniaturization in engineering materials and devices. Nanomaterials are classified according to the dimensions as zero-dimensional, one-dimensional, two-dimensional and three-dimensional nanomaterials. Of these one-dimensional materials like nanofibers are of great interest to the scientific world as its unique properties like high porosity, high surface area to volume ratio make it as a promising candidate for versatile applications in fields like environmental engineering, biotechnology and defense. The different processing techniques for nanofibers are drawing [1] template synthesis [2] phase separa-

tion [3] self assembly [4], Electrospinning [5] etc. Electrospinning is more advantageous in the sense that it helps in the mass production of long continuous fibers and also permits a good control over the morphology of fiber, its diameter and patterning of fiber deposition. This facilitates to cater the demands of certain specific applications like filtration membranes, opto-electronic devices, sensors etc. Eventhough electrospun fibers can be made of different materials; electrospun polymers both natural and synthetic remain the material of choices in the need based research as they can be suitably designed in pure and functionalized form and also they have an added advantage of no post-processing requisites. Among the synthetic polymers the vast extensively studied polymer is that of polystyrene mainly for adsorption of organic and inorganic pollutants. But the poor optic clarity, chemical and UV stability limits its applications. Poly(styrene-co-methyl methacrylate), a copolymer of styrene with methyl methacrylate is better alternative to

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PS nanofibers as they have improved physical properties. But the major challenge associated with the formation of nanofibers is to optimize the parameters like concentration, solvent type, applied voltage, flow rate, tip to target distance etc. [6] that determine the fineness of surface morphology.

In the present study the major objective is to optimize the parameters and to understand the concentration of the polymer, solvents and applied voltage for the fabrication of nonwoven nanofiber mat which can be tuned for filter media and optic applications. The polymer chosen is random copolymer of styrene and methylmethacrylate (PSMMA). PSMMA finds application in medicine, casting and automobile industries [7]. The selective sorption studies with PSMMA has been carried out but no work on PSMMA nanofibers have been reported to the best of our knowledge. Due to greater design flexibility and ease in synthesis, random copolymers are preferred over block copolymers for specific applications. Also random copolymers show the property of both the monomers.

2. Experimental

2.1. Materials and methods

Poly(styrene-co-methyl methacrylate) with average Mw 100,000–150,000 purchased from Sigma Aldrich, and the solvents Tetrahydrofuran (THF) and N,N-Dimethylformamide (DMF) were used for the study. The homogeneous polymer solutions for electrospinning were prepared by varying the concentration of the polymer and solvent ratio. The concentration studies were done by preparing PSMMA solutions of 3, 5, 10, 15 and 20 w/v percentages of polymer in 1:1 THF DMF mixture. The solvent selection studies were done with 3% (w/v) polymer in THFDMF mixture in the ratios 1:0, 7:3, 1:1, 3:7 and 0:1. The voltage studies were done with 3% (w/v) polymer solution in 1:1 THF DMF mixture by varying the applied voltage from 15 kV to 25 kV. In all these studies the electrospinning of the prepared solutions were done by fixing the flow rate and tip to target distance (d) as 0.5 ml/hr and 20 cm respectively. The fibers were collected on an aluminium foil and glass substrates. The entire electrospinning apparatus was enclosed in a glass box.

2.2. Characterization

The morphology of the fibers was investigated by using JEOL Model JSM – 6390 LV Scanning Electron Microscope (SEM) after sputter coating with gold. The thermal studies were done in Perkin Elmer STA 6000 under nitrogen atmosphere from room temperature to 700 °C at a heating rate of 10 °C/min and the UV-Visible studies were performed using UV-2600 UV-Visible spectrophotometer. Fourier Transform Infrared analysis was performed using Thermo Nicolet, Avatar 370 FTIR spectrometer.

3. Results and discussions

3.1. Structural studies

3.1.1. Applied voltage dependence on fiber morphology

The morphology of electrospun fibers was studied as a function of applied voltage to understand the optimum voltage for fiber for-

mation. The studies were performed by fixing the parameters like concentration of the polymer, solvent ratio, tip to target distance and flow rate as shown in Table 1. Fig. 1(a–c) show the SEM images of PSMMA nanofibers electrospun at different applied voltages of 15 kV, 20 kV and 25 kV respectively.

It can be seen that there is a remarkable change in the surface morphology of the fiber from electrospinning [8] to smooth fine fibers when the voltage is increased from 15 kV to 25 kV. This could be explained on the basis that the high voltage induced required charges which will help to overcome the surface tension of the solution thereby initiating the electrospinning process.

3.1.2. Solvent studies: effect of solvent ratio on fiber morphology

The solvent selection studies were performed by varying the ratios of the solvents chosen THF and DMF respectively as 1:0, 7:3, 1:1, 3:7 and 0:1. The parameters fixed for the study and morphology of fibers obtained are shown in Table 2. Fig. 2(d–g) shows the SEM images for fiber formation studies using the THF DMF ratio 1:0, 7:3, 3:7 and 0:1. Fig. 1(c) shows the SEM image of fiber formed under solvent ratio 1:1.

From the SEM images it is known that THF DMF solvent mixture in 1:1 ratio gave nanofiber with beadless morphology. It was reported elsewhere that solvent with greater dielectric constant reduces the bead formation and fiber diameter [9] and here the dielectric constant of DMF is higher. But it was observed that nanofiber prepared from greater ratio of DMF produced more beads than the fiber produced from greater proportion of THF. This may be because even though DMF has higher dielectric constant there may be retraction of polymer molecule owing to the poor polymer solvent interaction [10].

3.1.3. Concentration studies: effect of solution concentration on fiber morphology

The concentration studies were done by varying the concentration of polymer solution as 3, 5, 10, 15 and 20 wt/v percentages of polymer by fixing the other parameters as mentioned in Table 3. Figs. 1(c) and 3(h–k) show the SEM images of concentration 3, 5, 10, 15 and 20 wt/v respectively.

It was observed that bead free polymeric nanofibers were obtained for all concentrations studied at 25 kV. Also with increase in concentration from 3 (w/v) % to 20 (w/v) % there is significant change in the average fiber diameter from an average of 80 nm to 1100 nm as shown in Table 3. This may be because with increase in concentration the polymer chain entanglement in the solution will be greater that will sustain the stability of polymer jet [11]. The increase in fiber diameter with increase in concentration can be explained on the basis of greater viscosity. When the viscosity is high the secondary jets are prevented from breaking off the main jet resulting in increased fiber diameter [12].

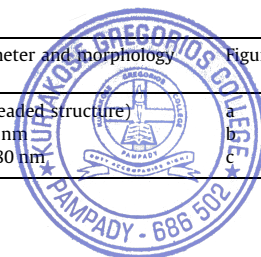
3.2. Thermal studies

Thermal studies were done as a function of fiber diameter. Fig. 4 shows the TGA curve of electrospun PSMMA fibers of average diameter 280 nm, 450 nm and 1100 nm represented as A, B and C respectively. It is seen that decomposition takes place in single step in all the samples. Also there is an increase in the onset, final and maximum degradation temperature of fibers with decrease in

Table 1

Conditions for Electrospinning for applied voltage studies.

Concentration (wt/v)	Applied voltage (kV)	Solvent ratio THF & DMF	Tip to Target distance d (cm)	Flow rate (ml/h)	Average fiber diameter and morphology	Figures
3%	15	1:1	20	0.5	Electrospinning (beaded structure)	
3%	20	1:1	20	0.5	Beaded fibers < 80 nm	
3%	25	1:1	20	0.5	Bead free fibers < 80 nm	



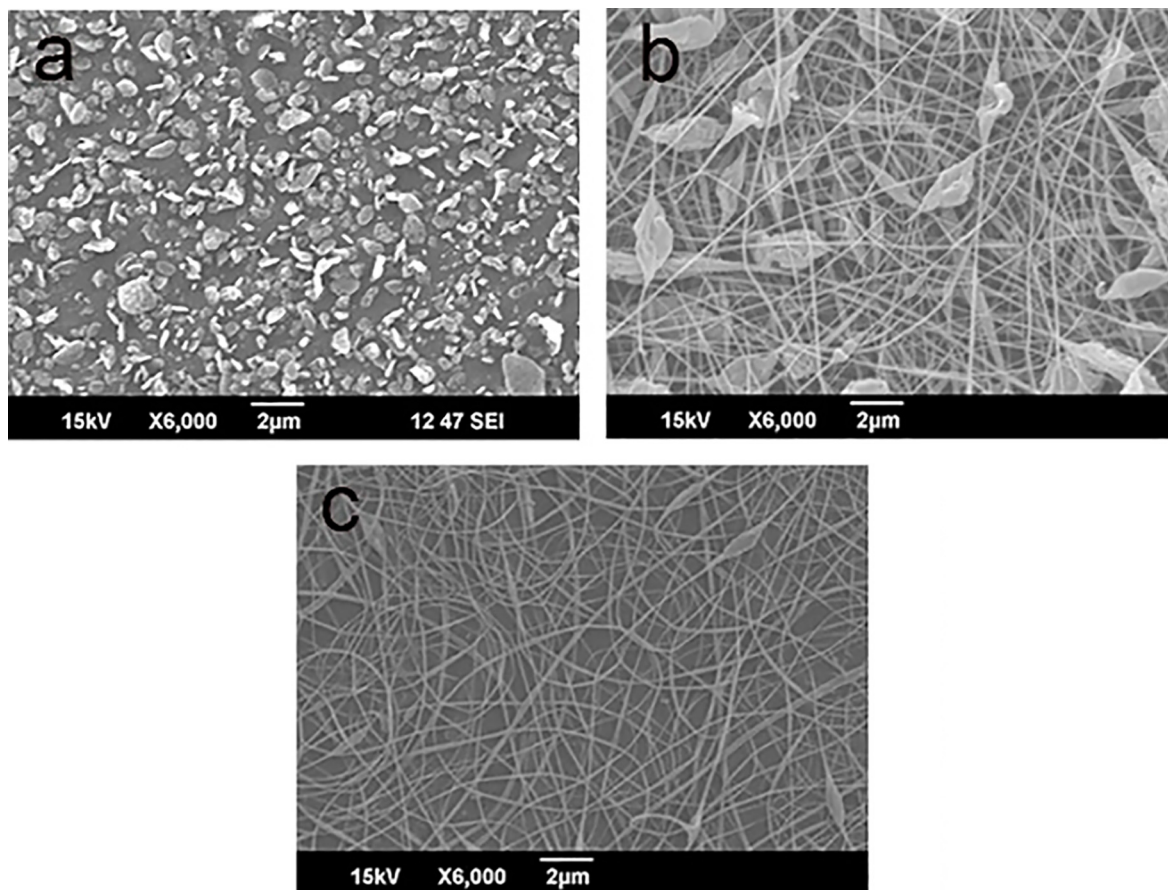


Fig. 1. SEM images as a function of applied voltage of PSMMA fibers (a) 15 kV (b) 20 kV (c) 25 kV.

Table 2

Conditions for Electrospinning for solvent studies.

Concentration (wt/v)	Applied voltage (kV)	Solvent ratio THF & DMF	Tip to Target distance d (cm)	Flow rate (ml/h)	Average fiber diameter and morphology	Figures
3%	25	1:0	20	0.5	Beaded fibers	d
3%	25	7:3	20	0.5	Bead free fibers < 160 nm	e
3%	25	1:1	20	0.5	Bead free fibers < 80 nm	c
3%	25	3:7	20	0.5	More beaded fibers < 140 nm	f
3%	25	0:1	20	0.5	Heavily beaded fibers	g

its diameter. It is also reported that for PSMMA copolymers the thermal stability is low because of the increase in the weak bonds [13].

3.3. UV-Visible absorption studies

UV-Visible absorption studies were done as a function of fiber diameter in the visible wavelength region. Fig. 5 gives the UV-Visible spectra of PSMMA fibers of average fiber diameter 280 nm, 450 nm and 1100 nm represented as A, B and C respectively. It is observed that fibers of different diameters absorb around 375 nm. But the absorption nature of fibers was found different. Even though the absorption maximum is not changed, the absorption intensity of the materials at different wavelengths found to be varied at different wavelengths.

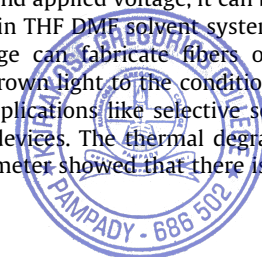
3.4. FTIR studies

FTIR analysis was performed to confirm the chemical composition of fibers Fig. 6. The peaks observed at $2989\text{--}2947\text{ cm}^{-1}$

corresponds to C–H stretching of methyl group. The peak at 1730 cm^{-1} is of C=O group in the ester part of PMMA [14]. The absorption peak at 1602 cm^{-1} is due to the stretching vibration of phenyl backbone in the polystyrene ring. The peaks at $1270\text{--}1000\text{ cm}^{-1}$ are assigned to C–H deformations, C–O–C and C–O stretching vibrations. The absorption peaks at $900\text{--}600\text{ cm}^{-1}$ originates from the C–H stretching of aromatic ring.

4. Conclusions

The main objective of the study is to optimize the solution parameters and processing parameters for the fabrication of PSMMA fibers. From the studies done with emphasis to polymer concentration, solvent selection and applied voltage, it can be concluded that 3% PSMMA solution in THF DMF solvent system electrospun at 25 kV applied voltage can fabricate fibers of good morphology. Also, the studies thrown light to the conditions that needed to fabricate fibers for applications like selective sorption of organic pollutants and optic devices. The thermal degradation studies as a function of fiber diameter showed that there is varia-



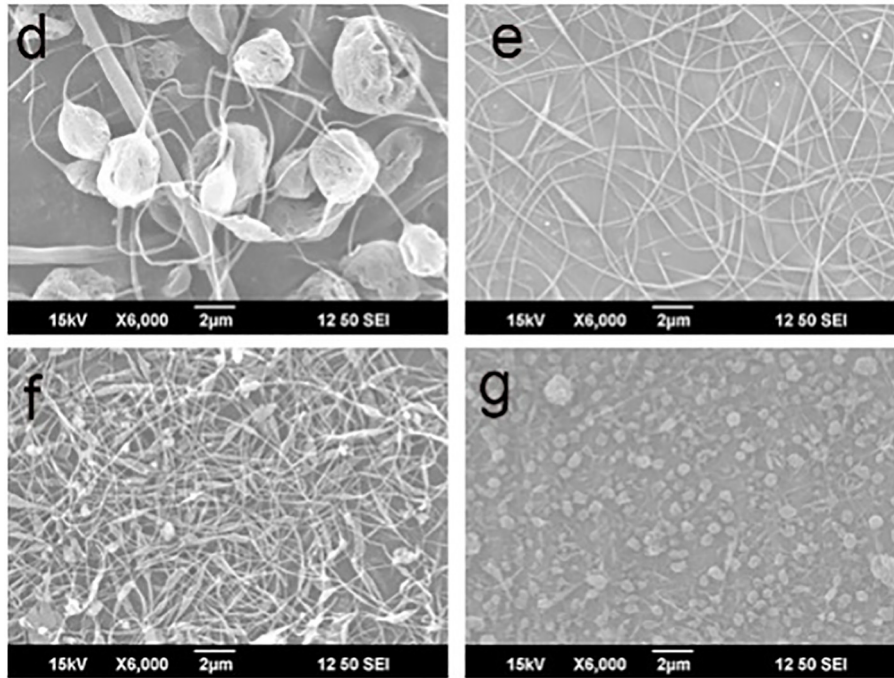


Fig. 2. SEM images as a function of THF:DMF ratio of PSMMA fibers (d) 1:0 (e) 7:3 (f) 3:7 (g) 0:1.

Table 3
Conditions for Electrospinning for concentration studies.

Concentration (wt/v)	Applied voltage (kV)	Solvent ratio THF & DMF	Tip to Target distance d (cm)	Flow rate (ml/h)	Average fiber diameter and morphology	Figures
3%	25	1:1	20	0.5	Bead free fibers < 80 nm	c
5%	25	1:1	20	0.5	Bead free fibers < 280 nm	h
10%	25	1:1	20	0.5	Bead free fibers < 450 nm	i
15%	25	1:1	20	0.5	Bead free fibers < 680 nm	j
20%	25	1:1	20	0.5	Bead free fibers < 1100 nm	k

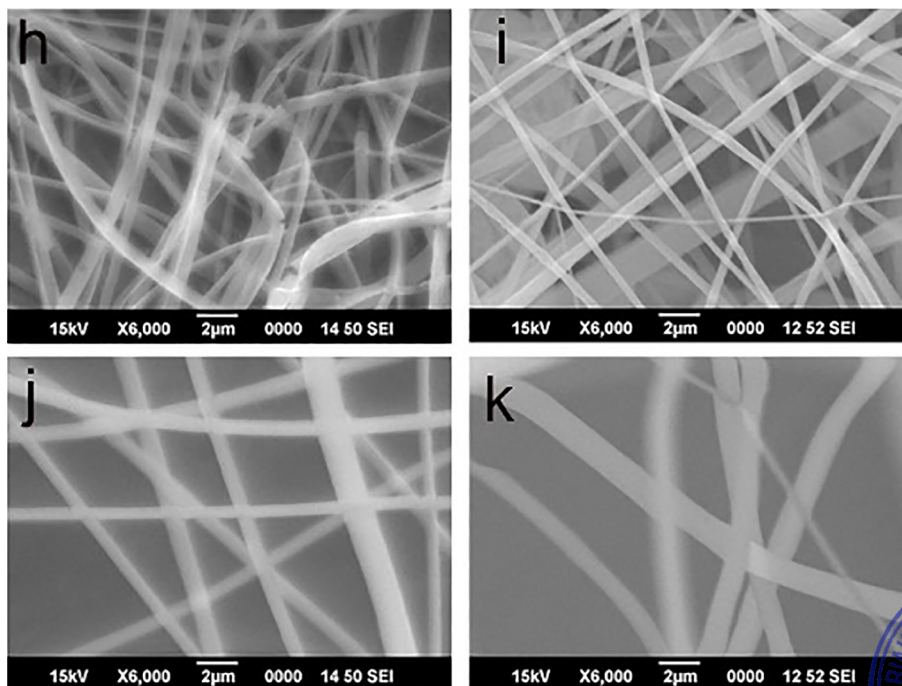


Fig. 3. SEM images as a function of concentration of PSMMA fibers (h) 5% (i) 10% (j) 15% (k) 20%



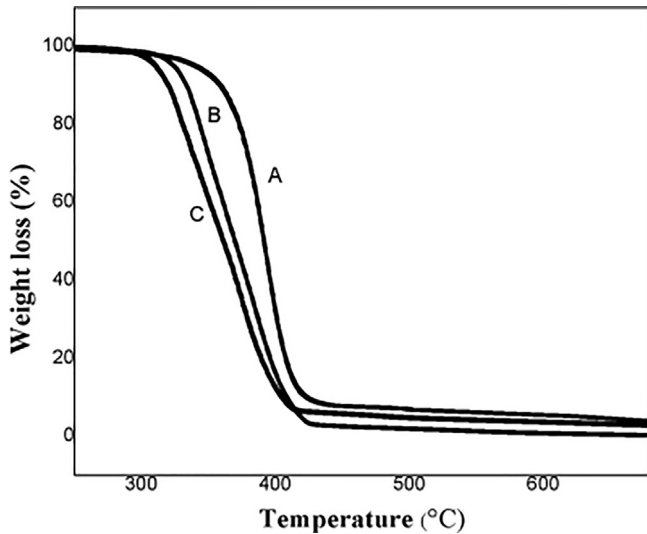


Fig. 4. TGA curve as function of average fiber diameter A, B and C represent 280 nm, 450 nm, 1100 nm respectively

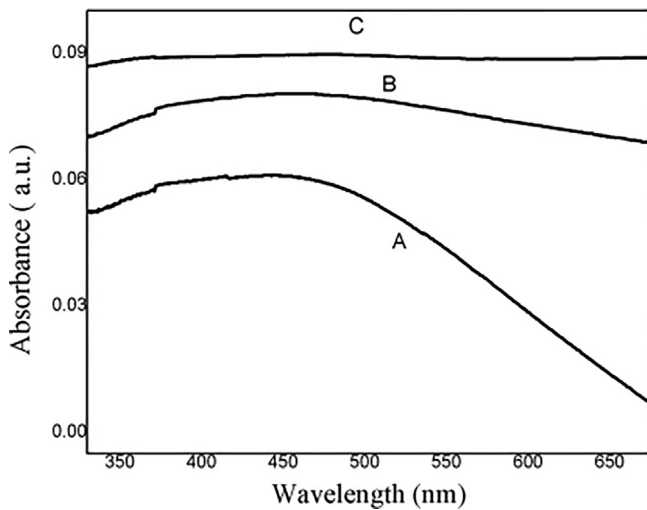


Fig. 5. UV-Visible absorption curve as function of average fiber diameter A, B and C represent 280 nm, 450 nm, 1100 nm respectively

tion in the degradation temperature with change in fiber diameter. Optical absorption studies also showed a change in the absorption intensities with change in fiber diameter. FTIR studies confirmed the structure of PSMMA.

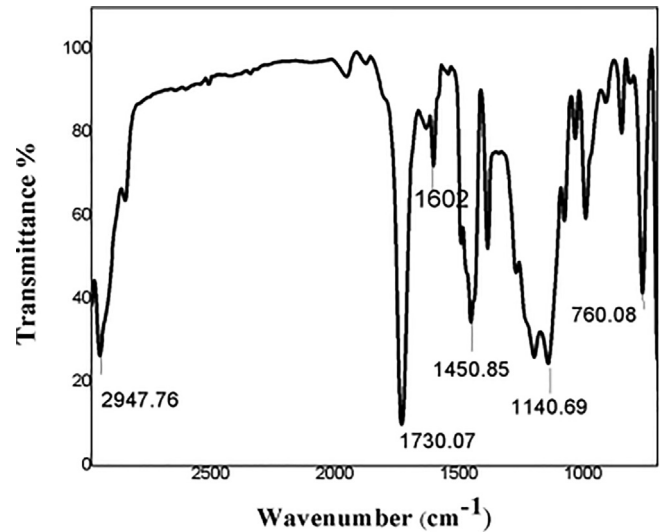


Fig. 6. FTIR image of PSMMA.

CRediT authorship contribution statement

Vinitha Varkey: Investigation, Validation, Writing - original draft, Writing - review & editing. **E. Tomlal Jose:** Methodology, Resources, Writing - review & editing. **U.S. Sajeev:** Formal analysis, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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A STUDY ON THE IMPACT OF RESPONSIBLE TOURISM ON THE ECONOMIC CONDITIONS OF HOME STAY OWNERS IN KUMARAKOM

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Abstract

Tourism is a fast growing industry in India. It is believed that Tourism has huge potential for revenue generation. But it is important to explore the untapped aspects of tourism . Providing Home stay arrangements can enable tourists to experience the rich culture and traditions of the host community too. This study is an attempt to know about the economic conditions of home stay owners in Kumarakom before and after responsible tourism.

INTRODUCTION

Tourism has been recognized as one of the prominent contributor towards the GDP of our country. In 2015, 44.2 billion US\$ was the direct contribution of tourism and hospitality sector to the Gross domestic product of our country. Trade, repair services, hotels and restaurants collectively forms the third-largest sub-segment of the services sector which contributed nearly US\$ 187.9 billion or 12.5 per cent to the Gross Domestic Product (GDP) in 2014-15, The Compound Annual Growth Rate (CAGR) over the period from 2011-12 to 2014-15 also shows significant progress. From the above figures we can easily understand that the Indian tourism and hospitality industry has emerged as one of the key drivers of growth among the services sector in India.

Apart from the contributions to the GDP, tourism is also considered to be important since, tourism in India has significant potential considering the historical importance of places, variety in ecology, culturally rich heritage sites, and naturally blessed beauty spots spread across the nation. Tourism is also a potentially large employment generator besides being a significant source of foreign exchange for the country.



Significance of the study

Apart from these positive aspects, when an area starts being visited by tourists, there are bound to be some social economic and cultural impacts of those tourists on the host community and economy of the destination . Locals may see increased congestion and overcrowding in towns and cities, perhaps an increase in crime, the introduction of new languages and values, and perhaps even an influx of migrant workers to be employed in the tourism industry. It is important to minimize these negative impacts and to focus more on positive aspects, such as promoting cultural exchange and preserving local traditions. This can usually be achieved by getting the locals involved in tourism. This is important from the view point of sustainability too as the locals will be more aware about the specialities of the location than any outsider. Having the community involved will not only offer visitors a more genuine experience, but offer a space where the locals will get an economic opportunity from tourism.

Economic sustainability means reducing leakages and building linkages—essentially, an attempt to keep the money local. A foreigner owned and operated hotel or restaurant is not likely to contribute much to the local economy. Much of the money gained will flow overseas. This is not sustainable. Therefore in responsible tourism ventures, guests are invited into the local houses where they get an opportunity to take rooms on rent, interact and share with the family members in the local household. This sort of accommodation is called as home stay.

Meaning of the term Home Stays

The home stay concept is ideal for visitors to experience the rural and traditional way of life, and for the local community to participate in and benefit directly from tourism. Home stays provide an authentic visitor experience that directly improves the lives and heritage of local Communities and aims to discover the nature and to enjoy the untouched and undisturbed country-side. The home stays are not hotels; instead they reflect the traditional and simple atmosphere of the rural lifestyle. Apart from the pleasure of being amidst peaceful and serene environment, tourists can also enjoy the tradition & culture of the rural hill communities.



Here the locals are also given a chance to gain from tourism without spending huge amounts on investments. This study is an attempt to know the socio economic conditions of home stay owners before and after their investment in tourism.

Objectives of the study

- To study about the economic conditions of home stay owners before and after their investment in tourism.
- To study about the association of literacy levels and income of home stay owners.

Hypotheses of the study are:

- H0 : There is no association between literacy levels and income of home stay owners.

Methodology

Primary data was collected from home stay owners who belonged to Kumarakom . Respondents were selected on a random basis based on convenience. Data collected through survey were supplemented with secondary data which were found relevant to make the study more significant. The questions were pertaining to the income levels of respondents before and after their initiatives in tourism ventures. Data was also collected to know the literacy levels of individuals who earned from tourism . For testing the hypotheses, chi-square tests were administered at 5% level of significance . The period of study was from October 2015 to November 2015.

Analysis and interpretation

Out of the 50 home stay owners surveyed, 40 were men and only 10 were women . Respondents were asked about their satisfaction regarding the earnings from their home stay businesses.

Table No 1. Showing Genderwise satisfaction of respondents

Entrepreneurs	Satisfied	Not Satisfied	Total
Men	25(50%)	15(30%)	40(80%)
Women	8 (16%)	2(4%)	10(20%)
Total	33(66%)	17 (34%)	50(100%)

Source: Primary data



Irrespective of the gender differences, large majority of the home stay owners were happy with what they got from tourism business . Majority of entrepreneurs in the home stay sector are men mainly because majority of the landholdings are held by men according to the patriarchal system being followed in Kerala. 66 % of the respondents were satisfied with their home stay business which amounts to a large proportion.

Engagements apart from tourism

It is very important also to know whether the respondents surveyed have some previous connections with the tourism or related industries. Previous working knowledge can influence the way things are handled in a business venture. Rural agriculture, trading and fishing activities should be integrated with the home stay business so that people who are not directly connected with tourism would also start to benefit from this tourism ventures. This integration would help eradicate poverty from the locals by deploying the foreign funds.

Table No.1 showing the other engagements of home stay entrepreneurs

Particulars	Number of Respondents	Percentage
Trading	12	24
Fishing	3	6
Business	05	10
Unemployed	05	10
Others	07	14
Agriculture	18	36
Total	50	100

36 % of the respondents depend on agriculture as their main economic activity along with home stays. This may be because of the agrarian nature of the kerala economy. 24% of the respondents were involved in trading activities. Traders should try to provide indigenous products which would attract the attention of tourists. If this is done, leakages can be minimized to the maximum possible extend.

Change in Income after engaging in tourism activity

Though agriculture was the main economic activity of the state, initiatives in the sustainable tourism development promoted the growth of many tourism related businesses . Questions were pertaining to the change in income after the beginning of home stays.



Table No. showing the income of home stay owners before and after their investments in tourism.

Annual Income levels of the family	Before	After
Upto 50,000	16	04
50,000-100,000	14	05
100,000- 200,000	12	20
200,000- 300,000	03	18
Above 300,000	05	07
Total	50	50

From the data analyzed, we can understand that the income levels have improved considerably. Respondents said that their returns from the home stay businesses are very good as they had to spend very little for the business developments. Children, Youth and the women folk also earn from the tourism initiatives of the home stay owners. Children can even earn by making garlands for the guests and by inviting them into the houses. Youth and the women folk can earn by preparing traditional delicacies for the guests. but they also pointed that they are finding it difficult to meet their ends meet during the off season periods. This may be because of the inefficient saving habits of the people. Mr A Varghese opined that savings can act as a source of income during off seasons for the seasonal income earners through his book 'Home management'.

Association Of Literacy Levels And Income Of The Home Stay Owners

Study was also done to know about the association of literacy levels and income of the home stay owners from tourism ventures. It is believed that education levels of a person can influence the way a person behaves and deal with people. People were surveyed and chi square tests was conducted to know the association of education and income generating capacity of home stay owners.



Table showing literacy levels and income of the home stay owners (in'000 s)

Particulars	Upto 50	50- 100	100 -200	200-300	Above 300	Total
Upto Higher secondary	06	07	09	00	01	23
Upto Graduation	01	04	05	01	00	11
Upto Post Graduation	00	02	02	01	01	06
Upto Professional Level	00	01	04	02	03	10
Total	07	14	20	04	05	50

Results

Chi Square Test Statistic

16.845

Degrees of freedom

 $(5-1)*(4-1)= 12$

Table Value

21.026

Calculated value is less than the table value, Therefore, we accept the null hypothesis. And it is understood hereby that they are independent .

From the analysis of primary data, we can understand that education levels have influence on the income generating capacity of the home stay entrepreneurs. Qualified people are able to earn more amounts by making use of all possible scientific tactics and integration of tourism with other activities. But there are people who are able to earn good numbers even while having a low educational qualification. This may be because of the entrepreneurial skills of the home stay owners

Findings of the study

- Irrespective of gender, home stay owners are satisfied with their earnings from the business.
- An integrated approach with other engagements is seen along with tourism. Rural agriculture and fishing are mainly integrated along with tourism in Kumarakom.
- Annual Income of home stay owners have increased considerably after their initiatives in tourism ventures.
- Education levels have an influence on the income generation capacity of home stays.



CONCLUSION

Local people organize and host the visitors and therefore are the primary recipients of the benefits, financial and otherwise, that build up from the tourism activity. In addition to the host families, many of the micro-enterprises in the locality can also get benefitted directly from the influx of tourists and increase demand for their products. The program also acts as an important mechanism to learn, share and conserve local values and customs. Such tourism activities provide direct economic benefits to the locals and make them participate in the conservation of the local environment that is the prime attraction for the tourists. Home stay Experience has potential in fulfilling niche segment market for both international and domestic tourists. Home stay Experience provides the local community with alternative incomes and becomes a poverty reduction tool.

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CUSTOMER EXPERIENCE FACTORS OF PUBLIC AND PRIVATE SECTOR BANKS IN KERALA

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Abstract: Customer experience arises out of the interactions that took place between customers and customer touch points. The possibility for multi-channel interactions in the banking sector demand for measuring customer experience at different touch points and its impact on the overall customer experience. The prominent players in the banking sector public sector banks and private sector banks have transformed themselves to provide better experiences. The present research compares the public and private sector banks with respect to the customer experience factors. The results of the study revealed that customer experience factors are present at varying intensity levels in the public sector banks and private sector banks. Core services of the private sector banks offer superior customer experience and differentiates private sector banks from public sector banks.

Key Words: Customer experience, Touch Points, Core Services, Value Added banking Services, Service Process.

I. Introduction

Technological developments in the 20th Century brought radical changes in all spheres and banks also have undergone this process. Banks the prominent financial service provider entered into a transition phase and the pace of the transition process was augmented by rapid technological revolutions. More over product and price differentiation, the major techniques used for attracting and retaining bank customers in the earlier times turned to be unsuccessful. For overcoming the challenges posed by rapid technological changes and differentiation strategies banks have incorporated fundamental changes in the basic operations. Further the possibilities for multichannel interactions with the banking organisations also demanded for more concentrated efforts for creating satisfied and loyal customers. Therefore offering positive customer experience at every contact points is identified as the measure, to overcome the issue of customer dissatisfaction and churn. (Tamilmaran, 2014) Customer experience is derived out of the presence of mechanical, functional, humanic and emotional clues present in the customer touch/contact points. (Garrett, 2006) Positive customer experience results in bondage with brand and ultimately would result in loyalty. (Pine & Gilmore, 1998) Offering customer experience is identified as the next battleground, especially for service organisations. The functional as well as operational differences that existed among the major players of Indian banking sector namely public sector and private sector got minimised due to the transition process and the similarities among them increased. Both public and private sector banks, began to offer better experiences in order to maintain their profitability and customer base. Customer touch/contact points of the banks are equipped with various clues that are capable of evoking various types of experiences among the customers. There is a dearth of research works on customer experience and especially that of banking customers. So this study attempts to bridge this gap by identifying the factors that contributes to the customer experience of both public sector and private sector banks. For the purpose of this paper is organised into five sections. First section gives the conceptual background of customer experience. Second lists out the significance, objectives, hypothesis and methodology of this study. Third section deals with factors influencing customer experience in the banking sector. Fourth section, the socio- demographic details and discriminant analysis of customer experience factors. Finally the study is concluded with results implication along with the study limitations and directions for future research.

II. Customer experience

Pine and Gilmore "Customer experience is an exchange of stimuli, information, and feelings between an organisation and its customers." Bernd H Schmitt "Customer experience consists of individual contacts between the firm and the customer at distinct points in the experience, called touch points". Meyer and Schwager defined the customer experience as "encompassing every aspect of a company's offering—the quality of customer care, of course, but also advertising, packaging, product and service features, ease of use, and reliability. It is the internal and subjective response customers have to any direct or indirect contact with a company"

III. Significance of the study

Provision of services and delivery of services which would influence customers at rational levels would no longer help banking organisations in the present era. Service performances, only by involving rational, emotional, affective and cognitive levels of the customers would result in long term profitability and loyalty among customers. The present research on factors influencing customer experience among public and private sector banks in Kerala is carried out to identify the prominent factor influencing customer experience. The present research would identify the most powerful customer experience factor in terms of its positive influence and will be helpful in formulating the policy and strategy formulators in the banking sector. Moreover in the banking sector where multi-channel interactions took place, information on customer experience at different touch points would help in determining the most effective touch point and also helps the bank authorities for devising strategies for modifying the existing touch points for offering better and improved new experiences to their customers. Moreover in a state like Kerala where financial inclusion percentage is more than 90% the determination of customer response towards customer experience factors would be crucial in maintaining existing customer base .

IV. Objectives of the study

1. To identify the most important factor influencing customer experience among banking customers in Kerala.
2. To determine the customer experience factors that differentiates public sector banks from private sector banks in Kerala.

V. Methodology

The present research on factors influencing customer experience among public and private sector banks in Kerala is exploratory in nature. For identifying the most important factor influencing customer experience data was collected from 400 customers each from public sector and private sector banks, who uses both offline and online platforms for fulfilling their banking requirements. The respondents were selected from three districts of Kerala, namely Trivandrum, Ernakulam and Calicut, adopting multi stage random sampling. A structured questionnaire consisting of 99 statements relating to 13 identified factors influencing customer experience is used for collecting the primary data. The 13 factors and 40 statements used in this research are adopted from the customer experience measurement scale developed by Ruchi Garg, Zillur Rahman, and M.N. Qureshi in 2014. The adopted factors as well as the statements are modified to suit the requirements of the present research. Cronbach's alpha of all the 13 factors influencing customer experience were above the acceptance level of 0.70 suggested by (Nunally,1978). Multiple discriminant analysis is applied to determine the most important factor influencing customer experience and also for identifying the factors that discriminates public sector banks from private sector banks.

VI. Customer experience factors

(Lemon & Verhoef, 2016) Customer experiences are generated from the interactions across customer contact points. After considering the customer touch / contact points equipped with various types of clues, presence of clues as well as its association with each customer touch points in banks thirteen factors are identified. Physical environment of bank branches and ATMs, convenience and ease of access of banking services, marketing mix, core services, value added banking services, branch employees, service process, customisation offered, customer interaction, speed of touch/contact points, aesthetic aspects of online & mobile banking services, hedonic elements of online & mobile banking services and functional elements of online & mobile banking services are identified as the factors that results in customer experience in the banking sector. Previous researches that have narrated the factors influencing customer experience is depicted in the Table-1 given below,

Table-1
Literature Evidence regarding factors influencing customer experience

Customer Experience Factors	Literature Evidence
Physical Environment of bank branches and ATMs	(Babin, Barry & Attaway, Jill, 2000)(Baker, Parasuraman, Grewal, & Voss, 2002)(Kim, Cha, Knutson, & Beck, 2011)(Kotri, 2011)(Garg, Rahman, Qureshi, & Kumar, 2012) (Garg, Rahman, & Qureshi, 2014)(Chang & Huang, 2014)(Yakhlef, 2015)(Backstrom & Johansson, 2006)
Convenience and Ease of Access of Banking services	(Bilgihan, 2010) (Kim et al, 2011)(Garg et al, 2012) (Rose, Clark, Samouel, & Hair, 2012) (Garg et al., 2014)(Nasution, Sembada, Miliiani, Resti, & Prawono, 2014) (Chang & Huang, 2014)
Marketing Mix	(Kotri, 2011)(Garg et al, 2012) (Garg et al., 2014)
Core Services	(Kotri, 2011)(Garg et al, 2012)(Garg et al., 2014)
Value Added Banking Services	(Garg et al, 2012) (Garg et al., 2014)
Bank Employees	(Harris, 2007)(Stewart, 2010)(Kotri, 2011)(Otnes, Ilhan, & Kulkarni, 2012)(Garg et al, 2012) (Garg et al., 2014) (Chang & Huang, 2014)
Customisation Offered	(Garg et al., 2012) (Rose et al., 2012) (Garg et al., 2014)
Customer Interaction	(Bilgihan, 2010) (Kotri, 2011)(Garg et al, 2012) (Otnes et al., 2012) (Garg et al., 2014)(Srivastava & Kaul, 2014)
Service Process	(Bitran, Ferrer, & Rocha, 2008)(Garg et al, 2012) (Garg et al., 2014) (Chang & Huang, 2014) (Joshi, 2014)
Speed of Contact/touch points	(Garg et al., 2012)(Rose et al., 2012) (Garg et al., 2014)
Aesthetic aspects of Online banking services	(Garg et al., 2012) (Rose et al., 2012) (Garg et al., 2014)
Hedonic elements of Online banking services	(Bilgihan, 2010)(Palmer, 2010)(Garg et al, 2012) (Garg et al., 2014)
Functional elements of Online banking services	(Bilgihan, 2010)(Garg et al, 2012) (Garg et al., 2014)(Hwang & Seo, 2016)



VII. Results and Discussion

7.1 Socio-demographic profile of customers

Table-2
Socio-demographic details of customers

Demographic Variables		Frequency	Percent
Gender	Male	431	53.88
	Female	369	46.13
Age	Below 20	80	10.00
	21-40	424	53.00
	41-60	259	32.38
	61 & above	37	4.63
Educational Qualification	SSLC/10	12	1.50
	Plus Two	80	10.00
	Undergraduate	236	29.50
	Postgraduate	321	40.13
	Doctoral degree	35	4.38
	Professional Degree	86	10.75
	Others	30	3.75
Occupation	Business	55	6.88
	Professional	62	7.75
	Government Employee	177	22.13
	Student	121	15.13
	Private Employee	291	36.38
	Others	94	11.75
Annual Income	Less than Rs.1,50,000	145	18.13
	Rs.1,50,001 to Rs. 3,00,000	82	10.25
	Rs.3,00,001 to Rs.4,50,000	167	20.88
	Rs.4,50,001 to Rs.6,00,000	199	24.88
	Rs.6,00,001 & above	207	25.88
Area of Residence	Corporation	283	35.38
	Municipality	252	31.50
	Panchayath	265	33.13
Years of association with the bank	Less than 5 Years	245	30.63
	6-10 Years	160	20.00
	11-15 Years	129	16.13
	16-20 Years	101	12.63
	21 Years & above	165	20.63

Source: Primary Data

7.2 Multiple discriminant analysis

In order to discriminate the factors influencing customer experience between public and private sector banks, at a time a Discriminant Analysis has been done. Discriminant function is a linear combination of the predictor variables that provide the best discrimination between the groups. In order to identify the important variables, variables with high coefficients, and pooled within group correlation between discriminating variables of the discriminant function are used. As the initial step in Discriminant Analysis, the Test to Equality of Group means is done to validate the power of each variable to the Discriminant Function. The following table-3 presents the results of tests of equality of group means and it was found that all the 13 variables selected are powerful enough to proceed with discriminant analysis. For identifying the customer experience factor that differentiates public sector banks from private sector banks the following hypothesis is formulated and tested as shown in Table-4 and Table-5.

The hypothesis is:

H_0 : There is no significant difference in customer experience factors between public and private sector banks.

H_1 : There is significant difference in customer experience factors between public and private sector banks.

Table-3
Tests of Equality of Group Means among type of banks

Variables	Wilks' Lambda	F	df1	df2	Sig.
Physical Environment of bank branches and ATMs	.738	283.324	1	798	.000
Convenience and Ease of Access of Banking services	.834	159.180	1	798	.000
Marketing Mix	.749	268.030	1	798	.000
Core Services	.658	414.797	1	798	.000
Value Added Banking Services	.748	268.660	1	798	.000
Bank Employees	.888	100.947	1	798	.000
Customisation Offered	.859	131.501	1	798	.000
Customer Interaction	.881	108.237	1	798	.000
Service Process	.871	117.819	1	798	.000
Speed of Contact/touch points	.917	72.158	1	798	.000
Aesthetic aspects of Online banking services	.835	157.920	1	798	.000
Hedonic elements of Online banking services	.859	130.492	1	798	.000
Functional elements of Online banking services	.890	98.306	1	798	.000

Source: Primary data

Table-4
Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	.710a	100.0	100.0	.644

a. First 1 canonical discriminant functions were used in the analysis.

Table-5
Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1	.585	424.731	13	.000

Table-6
Functions at Group Centroids

Type of Bank	Function
	1
Public Sector Banks	-.842
Private Sector banks	.842

Table-7
Standardized Canonical Discriminant Function Coefficients

Variables	Function
Physical Environment of bank branches and ATMs	.469
Convenience and Ease of Access of Banking services	-.215
Marketing Mix	-.127
Core Services	.748
Value Added Banking Services	.314
Bank Employees	-.212
Customisation Offered	.131
Customer Interaction	-.065
Service Process	.102
Speed of Contact/touch points	-.234
Aesthetic aspects of Online banking services	.018
Hedonic elements of Online banking services	.297
Functional elements of Online banking services	-.110



Table-8
Structure Matrix

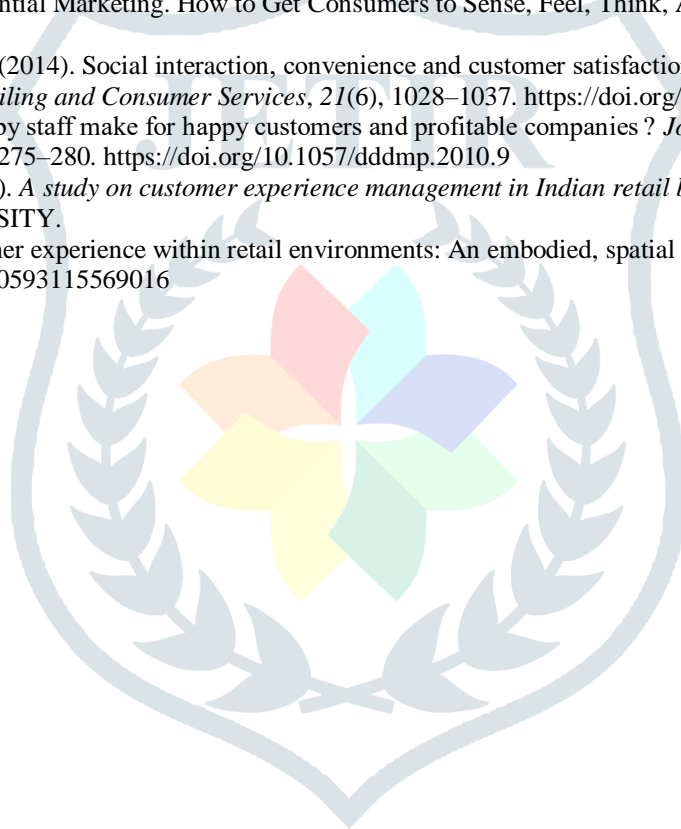
Variables	Function
	1
Core Services	.856
Physical Environment	.707
Value Added Banking Services	.689
Marketing Mix	.688
Convenience and Ease of Access of Banking services	.530
Aesthetic aspects of Online banking services	.528
Customisation Offered	.482
Hedonic elements of Online banking services	.480
Service Process	.456
Customer Interaction	.437
Bank Employees	.422
Functional elements of Online banking services	.416
Speed of Contact/touch points	.357

As per Table-3, test of equality of group means it is found that all the 13 customer experience factors are significant at the 1 percent significance level. Therefore all the 13 variables can be considered in the discriminant function. Table- 4 and Table-5 reveals the validity of the discriminant function. Validity of the discriminant function is based on Wilk's Lambda and F test. The smaller the Wilks' Lambda the more important the variable to the Discriminant function. Here, the Wilk's Lambda is found to be significant for all variables, since the F values are significant ($p < .01$). The Discriminant Function for customer experience factors of public and private sector banks is significant at the 1 per cent level with canonical correlation of **0.644** providing a $\chi^2 = 424.731$ with $p < 0.01$. The most important variable to the Discriminant function is core services (**Wilk's Lambda-0.658**) and therefore it can be inferred that core services offered by the bank is the major factor that influences the customer experience. The standardized canonical discriminant function coefficients and centroid values (Table- 4 and Table-5) shows that, the variables with negative coefficients are dominant factors influencing customer experience in public sector banks. Convenience and ease of access of banking services, marketing mix, bank employees, speed of contact/touch points and functional elements of online banking services are important among public sector banks. The other factors such as physical environment of bank branches and ATMs, core services, value added banking services, customisation offered, service process, aesthetic aspects of online banking services and hedonic elements of online banking services are dominant variables leading to superior customer experience in private sector banks. From the Table-8, it is evident that the variable with the highest positive correlation coefficient is core services (.856). Hence it can be concluded that the most important factor influencing customer experience is core services and also it is clear that core services discriminates against private sector banks from public sector banks. The present research gives a better idea about the factors influencing customer experience among banks. This gives better insights to bank managers while dealing with the customers so that they could manage customers more efficiently, offer excellent services resulting in superior customer experience.

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Power efficient approximate multiplier with reduced complexity using encoded partial products

Cite as: AIP Conference Proceedings 2222, 020007 (2020); <https://doi.org/10.1063/5.0003936>
Published Online: 16 April 2020

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Power Efficient Approximate Multiplier With Reduced Complexity Using Encoded Partial Products

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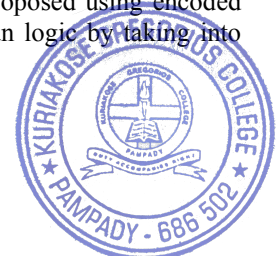
Abstract. Three major considerations for any VLSI design are power, area and delay. Several techniques have been proposed to reduce the power consumption. Approximate computing is an emerging technique for the design of power efficient systems which are suitable for error-tolerant applications. For many multimedia applications, inexact result is sufficient and hence approximate multipliers can be used for these applications. In this paper, an approximate compressor and half-adder based partial product encoded multiplier design is proposed. The proposed multiplier unit uses partial product encoding to reduce the logic complexity. Encoded partial products are reduced using approximate compressors and an approximate half-adder. Performance of the proposed multiplier is also compared with an exact and an existing approximate multiplier unit.

INTRODUCTION

Approximate computing is an emerging technique that has been used for improving the accuracy-performance trade-off in digital systems suitable for error-resilient applications [1]. Multipliers are the most often used computation blocks in digital systems, which consume most of the power. Approximation of multiplier units enables the design of power efficient systems. A multiplier has three implementation steps: partial product generation, partial product reduction and partial product accumulation. Among these 3 stages, partial product reduction stage is the most power consuming one. So, most of the approximate multiplier designs apply approximation to this stage [2]-[5]. All these approximate multipliers use either truncation [6]-[7] or approximation [2]-[5] in its partial product reduction stage.

The least significant columns of a partial product array can be truncated and to minimize the truncation error, a data independent term for error correction can be added [6]. The error correction term added is data independent, which leads to large error. Reduction in error can be achieved by introducing a data dependent correction term to the truncated product [7]. In the process of truncation, most of the bits are removed, which increases the error at final product. In this context, several approximation methods were introduced for the design of error tolerant, power-area efficient systems. The concept of approximation arise from an important paradigm of human brain that while doing computation intensive tasks, it is not sensitive to detailed behaviour of individual computational blocks used in system. This leads to use of approximate computation blocks for bio-inspired systems. In bio-inspired broken-array multiplier, approximation is applied to partial product accumulation stage [8].

Other methods of approximations involve use of approximate adders [2] and approximate compressors [3] for the reduction of partial products. All these methods mainly focus on direct application of approximate adders and compressors to reduce the logic complexity. In [4], a probability based design of approximate multiplier is proposed. This method alters partial products to introduce new encoded terms with different probabilities. Encoding is done to reduce probability of error during approximation. A low-power approximate multiplier is proposed using encoded partial products and approximate compressors in [5]. Encoding ensures reduction of Boolean logic by taking into



account of possible don't care logic states, thereby reducing circuit complexity. In this paper a 4-bit approximate multiplier is proposed in which, partial products are encoded with generate and propagate terms. The encoded terms are further reduced using approximate compressor for each stage [5].

In the proposed paper, further reduction in logic complexity of a 4-bit approximate multiplier is investigated. In the proposed design, partial products in the stages 1- 4 are encoded with propagate and generate terms followed by partial product reduction using approximate computational units. Approximate half-adder is proposed in reduction of stage 1 and approximate compressors in stages 2- 4. Circuit complexity is reduced in the proposed technique by increasing don't care logic states in stage 3.

PROPOSED ARCHITECTURE

Design of 4-bit Multiplier Unit

Consider two 4-bit unsigned operands $a = \sum_{i=0}^3 (a_i 2^i)$ and $b = \sum_{j=0}^3 (b_j 2^j)$. The partial product array is a (4×4) array of partial product bits $pp_{ij} = a_i \cdot b_j$, where $i, j \in \{0, 1, 2, 3\}$. Partial products for a 4-bit multiplication and their corresponding product bits are given in Figure 1 (a).

Partial product array is a 7-stage array for 4-bit multiplication. Partial products in the array are reduced to x_i and y_j for $i \in \{0, 1, 2, 3, 4, 5, 6\}$ and $j \in \{1, 2, 3, 4, 5, 6\}$ using full adders and half adders. Finally, these reduced partial products are accumulated using ripple carry adder.

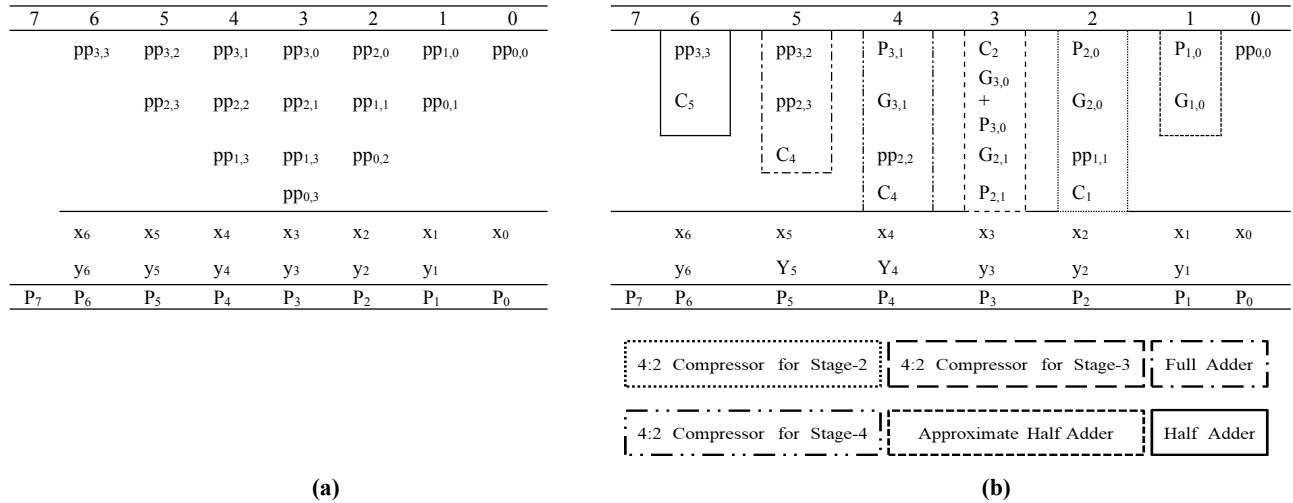


FIGURE 1. (a) Partial product array of un-signed multiplier (b) Encoded partial product array of proposed multiplier

In the proposed 4-bit approximate multiplier unit, some of the partial products are encoded. Propagate (P_{ij}) and Generate (G_{ij}) terms are used for encoding the partial products. Encoding is given by,

$$P_{i,j} = pp_{ij} + pp_{j,i} \quad (1)$$

$$G_{i,j} = pp_{ij} \cdot pp_{j,i} \quad (2)$$

Now actual partial product array is replaced with the encoded array and the partial products are reduced by using approximate half adders, approximate compressors, exact full-adder and exact half-adder. The encoded array is given in Figure 1 (b). In the encoded partial product array, C_1, C_2, C_3, C_4 and C_5 are the carry out from stage 1, 2, 3, 4 and 5 respectively. In this design, stages 2 and 4 have four inputs (3 partial products and a carry) and these stages are reduced using two approximate 4:2 compressors. In stage 3, there are 5 inputs which is reduced by using 4:2 compressor. Similarly, two encoded partial products of stage-1 are reduced using approximate half-adder. For other two stages, exact designs are used.



In the encoded partial products array, $P_{1,0}$ and $G_{1,0}$ are reduced using this approximate unit. Truth Table of the unit is given in Table 1. In the truth table, ‘√’ indicates true output and ‘x’ indicates false output. ‘NA’ represents don’t care logic states. Partial product encoding reduces circuit complexity by ensuring that certain input combinations never occur. Here, the encoded partial products for stage 1 are given by,

$$P_{1,0} = pp_{0,1} + pp_{1,0} \quad (3)$$

$$G_{1,0} = pp_{0,1} \cdot pp_{1,0} \quad (4)$$

TABLE 1. Truth table of Approximate Half-adder for stage-1

$P_{1,0}$	$G_{1,0}$	Sum	Carry
0	0	0 (√)	0 (√)
0	1	NA	NA
1	0	1 (√)	0 (√)
1	1	1 (x)	1 (√)

Consider (0,1) input combination of $(P_{1,0}, G_{1,0})$. From equation 4, $G_{1,0}$ is 1 only when $(pp_{0,1}, pp_{1,0})$ is (1,1). For $(pp_{0,1}, pp_{1,0}) = (1,1)$, $P_{1,0}$ is 1. So, $(P_{1,0}, G_{1,0})$ cannot have (0,1) input combination. Hence, this combination becomes don’t care. Increase in don’t care combination simplifies the logic function. Sum and Carry Outputs of this approximate unit is given by,

$$Sum = P_{1,0} \quad (5)$$

$$Carry = G_{1,0} \quad (6)$$

TABLE 2: Truth table of 4:2 compressor for stage-3

$C_2 (x_1)$	$G_{3,0} + P_{3,0}$ (x_2)	$G_{2,1} (x_3)$	$P_{2,1} (x_4)$	Sum	Carry
0	0	0	0	0 (√)	0 (√)
0	0	0	1	1 (√)	0 (√)
0	0	1	0	NA	NA
0	0	1	1	1 (x)	1 (√)
0	1	0	0	1 (√)	0 (√)
0	1	0	1	1 (x)	0 (x)
0	1	1	0	NA	NA
0	1	1	1	1 (√)	1 (√)
1	0	0	0	1 (√)	0 (√)
1	0	0	1	1 (x)	0 (x)
1	0	1	0	NA	NA
1	0	1	1	1 (√)	1 (√)
1	1	0	0	1 (x)	1 (√)
1	1	0	1	1 (√)	1 (√)
1	1	1	0	NA	NA
1	1	1	1	1 (x)	1 (x)

Stage-3 has four encoded partial products plus a carry out from stage-2. These terms are reduced using a newly proposed approximate compressor with truth table given in Table 2. Since, five inputs are available for reduction, these are initially reduced to four as given below,

$$x_1 = C_2; x_2 = G_{3,0} + P_{3,0}; x_3 = G_{2,1}; x_4 = P_{2,1} \quad (7)$$

In the previous work [8], the input combinations are,

$$x_1 = C_2; x_2 = G_{3,0} + G_{2,1}; x_3 = P_{2,1}; x_4 = P_{3,0} \quad (8)$$

On changing the input combinations as given in equation 7, number of don’t care combinations of the proposed design has increased (2 more) compared with the previous design. This further simplified the logic function and reduced the power consumption. The number of faulty outputs for Sum reduces from 6 of the previous design to 5 of



the proposed design. Similarly, number of faulty outputs for Carry is 2 less than the previous design. When the input combination as given in equation 7 is used, all (1,0) combination for $(G_{2,i}, P_{2,i})$ becomes don't care. Outputs of the compressor is given by,

$$Sum = x_1 + x_2 + x_4 \quad (9)$$

$$Carry = x_1 \cdot x_2 + x_3 \quad (10)$$

For stage-2 and stage-4 reduction, two separate approximate compressors are used in our design. Stage-2 of partial product array has three partial products plus a carry out from stage-1. Output function is given by,

$$Sum = P_{2,0} + pp_{1,1} \quad (11)$$

$$Carry = G_{2,0} + C_1 \quad (12)$$

$P_{2,0}$, $G_{2,0}$, $pp_{1,1}$ and C_1 are the inputs to this compressor.

Stage-4 has three partial products plus carry out from stage-3. Like stage-2 and stage-3 compressor, a stage-4 approximate compressor is used for reduction of these partial products. Inputs to this compressor are $P_{3,1}$, $G_{3,1}$, $pp_{2,2}$ and C_3 . Output function is given by,

$$Sum = P_{3,1} + G_{3,1} + pp_{2,2} \quad (13)$$

$$Carry = G_{3,1} + pp_{2,2} \cdot C_3 \quad (14)$$

Higher Order Multiplier Design

To construct $(2n \times 2n)$ multiplier from the designed n -bit multiplier, each $2n$ -bit operands A and B are divided into four n -bit groups such as A_L , A_H , B_L and B_H . A_L and B_L represent LSBs, A_H and B_H represents MSBs of A and B respectively. Each of the n -bit groups are multiplied using n -bit multiplier as shown in Figure 2 [9]. Partial products are then shifted and accumulated to get final result.

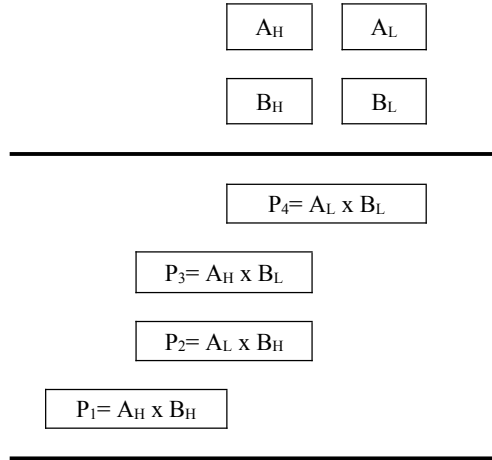


FIGURE 2. Scaling to Higher Order Multiplier

In this work, we proposed 8-bit multiplier units by scaling 4-bit units as shown in Figure 2. Along with this for comparison, exact and existing multiplier units were also synthesized. Scaling of all multipliers synthesized in this work is given in Table 3. M_P is the 4-bit proposed unit and M_E is the 4-bit existing unit [5].

TABLE 3: Higher Order Multiplier Designs

Size	Design	P1	P2	P3	P4
8 × 8	M_{P8}	M_P	M_P	M_P	M_P
	M_{E8}	M_E	M_E	M_E	M_E



RESULTS AND ANALYSIS

Simulation Results

Proposed 4-bit multiplier is designed and simulated in Cadence tool. Simulated waveforms, RTL schematic and power report of this unit is shown in Figure 3 and 4. The proposed unit consist of 4 partial product encoding blocks, 3 approximate compressors, an approximate half-adder, a half-adder and a full-adder. In the simulation waveform a and b are the 4-bit input operands and y is the 8-bit output operand.

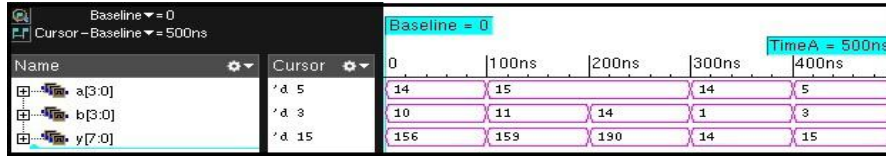


FIGURE 3. Simulation output of proposed 4-bit unit (M_P)

Hardware Analysis

Comparison of all multiplier units in terms of power, delay and area is given in Table 5. All multiplier designs were designed in Verilog. Simulation and synthesis of designs were performed using Cadence design tool for 180nm technology at supply voltage of 1.2 V and using Xilinx ISE 14.7.

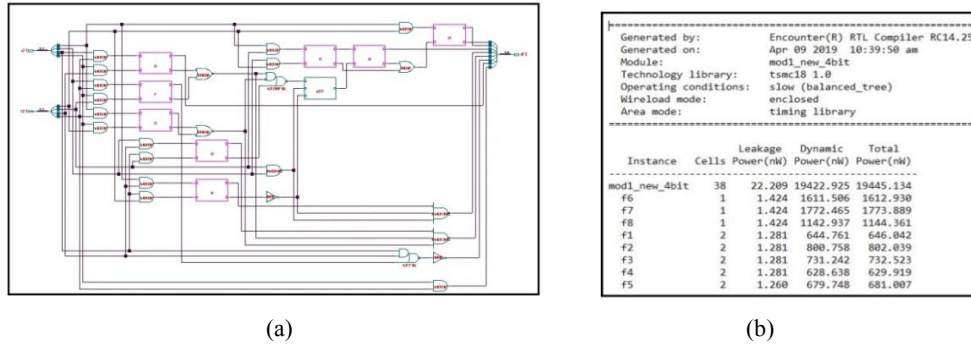


FIGURE 4. (a) RTL Schematic of proposed 4-bit unit (M_P) (b) Power report of proposed 4-bit unit (M_P)

TABLE 4. Hardware comparison of multiplier units

Size	Multiplier Type	Power (μ W)	Number of slices used (out of 768)	Delay (ns)
4×4	M_P	19.445	11	11.001
	$M_E[5]$	21.645	13	12.057
8×8	M_{P8}	168.25	62	20.508
	M_{E8}	173.14	67	21.483
	$Exact_8$	346.89	88	28.980

Accuracy Analysis

Mean relative error distance (MRED) is the error metric used to quantify accuracy of the designed unit [10]. It is defined as the average of all relative error distance values (REDs) over entire input space. MRED of an n -bit multiplier is,

$$MRED = \frac{1}{2^{(2n)}} \sum_{i=1}^{2^{(2n)}} \frac{RED}{R} \quad (15)$$



where, relative error distance (RED) of the design is,

$$RED = \frac{ED}{R} \quad (16)$$

Error distance(ED) is defined as the difference between exact and approximate result. If R denotes the exact result and R' denotes the approximate result then error distance is,

$$ED = |R - R'| \quad (17)$$

4-bit approximate units M_P and M_E are simulated over entire input space (256 cases) and MRED values obtained are given in Table 5.

TABLE 5. Accuracy Comparison of multiplier units

Multiplier Type	Size	MRED
Proposed (M_P)	4-Bit	0.0561
Existing (M_E)[5]	4-Bit	0.0534

From the comparison tables 4 and 5, it can be concluded that, with a slight increase of about 0.003 in MRED value, power consumed by proposed 8-bit approximate multiplier unit is about **51%** less than that of exact design and **3%** less than that of existing design.

CONCLUSION

A 4-bit approximate multiplier unit is proposed and designed. Proposed unit used partial product encoding, 3 approximate compressors and an approximate half-adder for approximation. For performance evaluation, exact and existing approximate units are also designed. Power reports showed that power consumption of proposed 8-bit unit is about 51% less than that of exact unit and 3% less than that of existing unit. MRED of proposed 4-bit unit is only 0.003 less than that of existing unit. Hence, the proposed approximate multiplier unit provides power efficiency without much affecting accuracy.

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IMPACT OF FLOOD ON AQUA CULTURE SYSTEMS IN WAYANAD DISTRICT

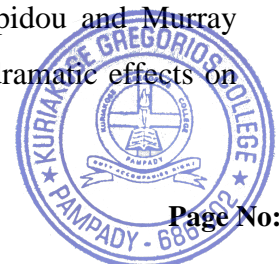
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Inland fish production is an area which holds promise for future in Kerala. It provides significant contribution to animal protein supplies in rural areas of the state. Aquaculture sector had been gaining momentum for the past two years but the flood has stalled all progress. The study is basically focused to know the impact of flood by the comparative study of the inland fish farming systems in Wayanad district. The flood not only washed away the crops but also a large number of fishes in aqua culture systems. By the time the water receded, majority of the fish had escaped. Some got stuck in the net and perished. The time at which the flood happened is the actual time for the stocking of the fish seed. The fishes with harvesting stages also lost due to the over flow of water. During the flood most of the farms and hatcheries were submerged. It also damaged fishing equipments and caused irreparable damages to the total infrastructure. The loss due to flood in the aquaculture sector will affect the total fish production in the current year.

Keywords: Inland fish production, Aquaculture, Impact of flood

INTRODUCTION

Natural disasters such as flood is considered as a severe disaster event which occurs mainly because of natural causes or man-made causes or a combination of both events. It causes extensive damage to human life and property along with loss of flora and fauna.(Janani et al 2016) Flooding is usually considered a significant natural hazard causing disease, injury and loss of humanity, injury to property and various kinds of infrastructure and public utility services. For instance, flood devastations could cause serious landslides (Hong et al. 2007), damage to crops and different kinds of livestock (Atta-ur-Rahman 2011), interruption of routing draining mechanisms (Ogden et al. 2011), drainage of raw sewage and animal wastes, and accelerated effluent of discharges from industrial units and other toxic materials (Euripidou and Murray 2004) and essential nutrients into waterways (Hubbard et al. 2011). Due to dramatic effects on



society and social and economic modes of infrastructure, the effects of flooding on aquatic ecosystems are viewed as negative; But, this is not always applicable. Flooding provides many benefits, including recharging groundwater, enhancing fish production, maintaining and forming wildlife habitat, recharging wetlands, creating floodplains, and recharging soil fertility (Poff 2002). As the effects of flooding on the aquatic ecosystems is both negative and positive, ecosystem services could exhibit a combination of negative and positive results derived from flooding (Terrado et al. 2013). The rivers need flood to create vital habitat and support biological diversity and biodiversity. The Flood Pulse Concept states that predictable seasonal floods are beneficial for riverine systems and can influence biotic composition, nutrient transport, and sediment distribution but unpredictable floods may be disruptive for aquatic organisms (Junk et al. 1989). In addition, several aquatic ecosystems led to increased resilience capacity to the future vulnerable events namely, flooding because of human interventions which include urban development and farming practices on floodplains, river flow interruptions, and pollution (Woodward et al. 2016) There are many studies that evaluate the effects of disturbances on ecosystem services, but most of these studies focus on terrestrial systems and there are few that look at aquatic ecosystem services (Grizzetti et al. 2016).

A large numbers of a community depend upon fisheries sector which contributes a decent amount in state income. In this year 2018, the monsoon hits critically in the south-west state especially Kerala region in India which results in severe flooding in nearly a century (Baynes, Chris, 2018) , affecting overall 14 district of the state due to heavy rainfall. Approximately over 373 people died within last 15 days and around 280,679 people were emigrant (Babu, Gireesh, 2018), mainly from Aranmula, Aluva, Chalakkudi, Kuttanad, Pandalam, Chengannur, Pandanad and other districts etc. For the first time in history around 35 out of 42 dams in the state of Kerala were opened due to overflow particularly Wayanad and Idukki regions where floods caused several landslides and isolated the hilly regions (India today, Mathrubhumi 2018). Inland fisheries is one of the promising farming activity on these hilly districts. The study is basically focused to know the impact of flood by the comparative study of the inland fish farming systems in Wayanad district. The flood not only washed away the crops but also a large number of fishes in aqua culture systems in Wayanad districts.



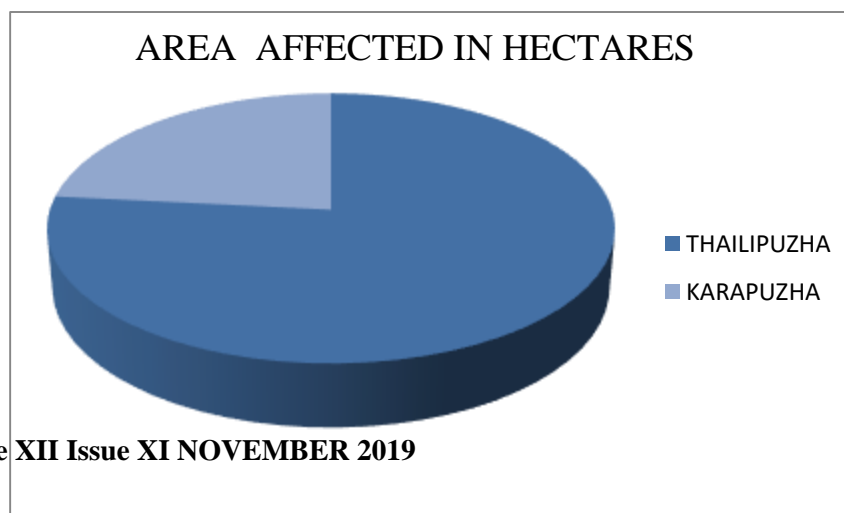
METHODOLOGY

Wayanad district stands on the southern tip of the Deccan plateau and includes part of the Western Ghats with altitudes ranging from 700 to 2100 meters. The district is blessed with rich water resources. In the study area there are rivers flowing from the west. It is the major river in the district. In addition, the river flowing rivers in Kerala. Kabani has many areas such as Thirunelli River, Panamaram River and Mananthavady River.

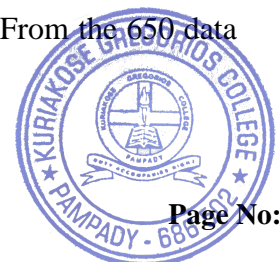
The study is mainly done using the secondary data collected from the publications of Government of India and Directorate of fisheries Wayanad. Using questionnaire method, the impact of flood on different aquatic systems and aquaculture systems on this district was analyzed. For the easy study, the areas of Wayanad district has been subdivided into two regions namely Karapuzha and Thalipuzha. In order to check the effect of flood, the questions which are prepared by fisheries department was handover to promoters of different panchayaths. Data were collected by promoters through face to face interview (questionnaire) with the aquaculture farmers. The questionnaire contained three main sections. The first section was designed to collect information on personal characteristics of farmers including age, address, contact details, education level etc. The second level focused on the farming activities. The third section included the impact of flood on their farming area and Government support to flood effects. The secondary datas of 650 farmers are collected and analyze the impact of flood on their farming systems.

RESULTS AND DISCUSSION

The purpose of the study is to evaluate the effect of flood on different regions of Wayanad district where the fish cultivation occur. By the comparative study through the 2 units in Wayanad ie; Thalipuzha and Karapuzha, the flood has been negatively affected to the fish

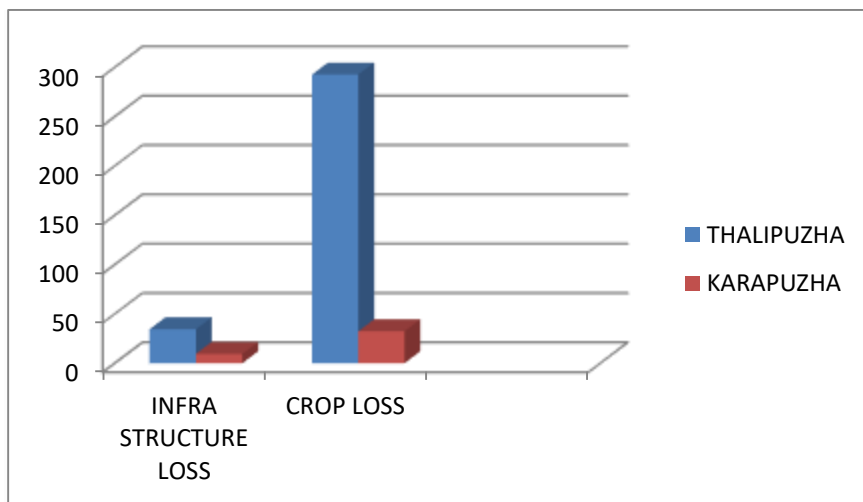


farming systems and Aquatic systems in Wayanad district. For the study about 7 kinds of farming systems are analyzed. From the 650 data



collected 611 farmers are the victim of flood effects. The flood not only washed away the agricultural crops but also a large number of fishes in aqua culture systems. From the data we can predict Thalipuzha region was highly affected to flood. Because, the Banasura Sagar dam, which is the largest earthen dam in India located in Vythiri thaluk, as a result of heavy rain the shutters of dam was opened. That will create overflow of water to nearby areas. Padinjarathara was the most flood affected area in Wayanad district.

By the time the water receded, majority of the fish had escaped. Some got stuck in the net and perished. The time at which the flood happened is the actual time for the stocking of the fish seed. The fishes with harvesting stages also lost due to the over flow of water. During the flood most of the farms and hatcheries were submerged. It also damaged fishing equipments and caused irreparable damages to the total infrastructure. The loss due to flood in the aquaculture sector will affect the total fish production in Kerala.



We expected to find that floods magnitude plays a role in determining whether aquatic ecosystem services are lost or gained following flood events. It is speculated that even small extent of floods is responsible for effects on eco system and the extreme flooding leads to severe losses. If ecosystem services respond to small and extreme magnitude floods differently, then current flood mitigation strategies may be detrimental to aquatic ecosystem services. The tasks such as common flood reduction programmes namely, dam building and other flood constraints implementation reduce the occurrence of small amount of floods but it is said that unable to minimize the effects of extreme amount of floods. (Alferi et al. 2016).



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AUGUST 1, 2019



Factors affecting the work-family-life conflict of Bank Employees in Kerala

By P.N. Hari Kumar and Vipin K. Varughese*

In this era of globalisation the boundaries of the world are disappearing, especially with respect to work. At present, global organizations are working 24 X 365. Everyone's focus is more on the work than the personal life, which is creating an imbalance between the professional work and the personal life. Work-life and personal life are two sides of life. In various work-life balance surveys, the majority of the employees said that they were not able to strike a balance between their personal and professional lives. They had to form robust selections, once their work and private life is obscurity were about to reach an equilibrium. Increasing work pressures, globalisation and technological advancements have made it an issue to all professionals working across all levels and all industries throughout the world. Achieving a level of work-family-life balance is not as easy as any other work.

Work-life balance is an important element in managing the work-family-life conflict of all employees. There is a conflict between the official life, personal life, family life and social life of all employees. In official life, the bank employees have problems related to customers' service, job, subordinates or colleagues, superiors and management, strain (stress), infrastructure, non-banking activities etc. Lack of career growth and development, physical strain, etc. are the problems faced by the employees in personal life. In family life, the employees face problems related to caring parents, child care, spouse support and day-to-day activities of the household.

Unhealthy relationship with friends and relatives, and nonparticipation in social activities are the problems faced by an employee in his social

life. Every employee desires a balance between the official, personal, social and family life. A balance between these four elements create happiness and peace in the work – family-life of a person. The happiness, satisfaction and peace motivate the employee to work effectively. It reduces the employee burnout. The effective work of an employee helps the organisation to attain its goals. This study tries to describe the factors affecting the work-family-life conflict using collected data from selected 550 bank employees in Kerala using questionnaire.

In this research paper, the demographic profile of the selected bank employees in Kerala and the problems of the workplace leading to work-family-life conflict is presented.

Objective

The main objective of the paper is to identify the various factors affecting work-life conflict and family-life conflict.

Methodology: Primary data have been used for this study, which are

collected from 550 selected employees with a well-designed questionnaire, the employees were selected by applying Two-stage random sampling method.

Tools

The collected data were analysed with appropriate statistical method such as step-wise multiple linear regression model.

Demographic Profile of Bank employees

The profile of respondents explaining the occupational features of bank employees is presented in the Table-1 exhibits the profile of the sample respondents (employees) selected for the study. As per the Table, while 54.5 per cent of the respondents belong to Public sector banks, 27.3 per cent belong to old private sector and the remaining 18.2 per cent belong to new generation private sector banks. Designation-wise classification shows that 42.7 per cent are clerks cum cashiers, 35.5 per cent are junior managers and 21.8 per cent are senior managers.

* Dr. P.N. Harikumar, Associate Prof. & Head and Mr. Vipin K. Varughese, FDP Research Scholar, both are from Research & Post-graduate Department of Commerce, Catholicate College, Pathanamthitta, Kerala.

Table-1
Occupational Profile of Bank Employees

	Categories	Frequency	Percent
Type of bank	Public Sector	300	54.5
	Old Private Sector	150	27.3
	New Private Sector	100	18.2
	Total	550	100
Designation	Senior Manager	120	21.8
	Junior Manager	195	35.5
	Clerk cum cashier	235	42.7
	Total	550	100
Experience	below 5 years	145	26.4
	5-10	174	31.6
	11-15	62	11.3
	16-20	38	6.9
	21 & above	131	23.8
	Total	550	100
Location	Urban	146	26.5
	Semi urban	366	66.6
	Rural	38	6.9
	Total	550	100
Distance between Residence to branch	below 10 km	250	45.5
	11-20	147	26.7
	21 & above	153	27.8
	Total	550	100
Number of hours worked per day	7 hrs	95	17.3
	7-9	240	43.6
	above 9	215	39.1
	Total	550	100
No. of transfers in service	Nil	54	9.8
	1-2	160	29.0
	3-5	200	36.4
	6-7	52	9.5
	above 7	84	15.3
	Total	550	100

Table-2
Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
7	.862g	.744	.739	5.40201

g. Predictors: (Constant), negative attitude of family, occupational stress, difficulty of time management, more number of customers, ineffective communication, nature of the job, no control over the work

Table-3
ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
7	Regression	31907.011	7	4558.144	156.198	.000h
	Residual	11001.524	377	29.182		
	Total	42908.535	384			

h. Predictors: (Constant), negative attitude of family, occupational stress, difficulty of time management, more number of customers, ineffective communication, nature of the job, no control over the work

Table-4
Coefficients^a

Model		Unstandardized Coefficients B	Standardized Coefficients Std. Error	Beta	t	Sig.
	(Constant)	1.092	1.364		.801	.424
	Negative attitude of family	.423	.032	.502	13.062	.000*
	Occupational stress	.365	.052	.273	6.966	.000*
7	Difficulty of time management	.254	.043	.247	5.922	.000*
	More number of customers	.264	.066	.117	4.003	.000*
	Ineffective communication	.252	.069	.126	3.640	.000*
	Nature of the job	.147	.040	.134	3.719	.000*
	No control over the work	.067	.029	.108	2.285	.023*

a. Dependent Variable: Work-life conflict

*Significant at 5 per cent level



Experience-wise classification depicts that 31.6 per cent of employees have 5-10 years of experience, 26.4 per cent have less than 5 years, 23.8 per cent have 21 and above, 11.3 per cent have 11-15 years and 6.9 per cent have 16-20 years of experience in banking. It is found that 66.6 per cent of the employees work in semi-urban branches, 26.5 per cent in urban branches and 6.9 per cent in rural branches. An analysis of distance from residence to bank revealed that about 46% reside within 10kms, while about 27% reside in areas which are 2km and above from the bank they work. An analysis of working hours revealed that about 44% work 7-9 hours a day and about 18% work for more than 9 hours. To the query on transfers, about 36% stated to have been transferred about 3-5 times, 15% stated to have been transferred for more than 7 times and about 10% stated they have not been transferred.

Work-life conflict

Work-life conflict means the conflict arising in the official life due to various factors. Indifferent customers' approach, more number of customers, nature of the job, no clarity in job, no control over the work, no sharing of job, lack of team work, lack of support from subordinates/colleagues, negative approach of top management, indifferent attitude of superiors, ineffective communication, difficulty of time management, negative attitude of family, mental strain (stress), physical strain, and occupational stress are the factors that create work-life conflict. The impact of these factors on work-life conflict is analysed with the help of step-wise multiple linear regression model and the results are presented in Tables 2, 3 and 4.

The factors affecting the work-life conflict and the impact of such factors were measured by using the step-wise multiple linear regression model. The R^2 clearly indicated that 74.4 per cent of the variation of work-life conflict was due to the effect of seven factors as per the 7th model. The output also indicated that only seven factors affected the work-life conflict, as the beta co-efficients and the associated t values were significant (Beta co-efficients .423, .365, .254, .264, .252, .147 and .067 and associated t values 13.062, 6.966, 5.922, 4.003, 3.640, 3.719 and 2.285 with $P < .05$ in all cases). So, it may be concluded that the negative attitude of family, occupational stress, difficulty of time management, more number of customers, ineffective communication, nature of the job, and no control over the work create the work-life conflict among the employees of banks.

Family-life conflict

The factors creating family-life conflict such as, customers approach, more number of customers, nature of the job, no clarity in job, no control over the work, no sharing of job, lack of team work, lack of support from subordinates/colleagues, negative approach of top management, indifferent attitude of superiors, ineffective communication, difficulty of time management, negative attitude of family, mental strain (stress), physical strain, and occupational stress and their impact on family-life conflict were analysed with the help of step-wise multiple linear regression model and the results are presented in Tables 5, 6 and 7.

The factors affecting the family-life conflict and its impact were identified by applying the step-wise multiple

linear regression model. The output of the fourth model indicates that the R^2 was .450 which means that 45 per cent of the family-life conflict could be explained by the four factors, viz., indifferent attitude of superiors, mental strain, negative approach of top management, and no sharing of job. Here, it was also seen that the positive beta co-efficient and its associated t value were significant statistically at 5 per cent level (Beta co-efficients 0.196, 0.459, 0.206 and 0.221 and associated t values 4.310, 5.924, 5.340 and 2.216 with $P < .05$ in all these cases). Therefore, it could be inferred that family-life conflict of bank employees was affected by indifferent attitude of superiors, mental strain (stress), negative approach of top management, and lack of job sharing.

Conclusion

In this research paper the work-life balance of public and private sector bank employees has been under study. Here, the main factors affect the work-life conflict and family-life conflict of the employees are identified. Negative attitude of family, occupational stress, difficulty of time management, more number of customers, ineffective communication, nature of the job, no control over the work are the factors that create work-life conflict among the employees of banks, while the family-life conflict arises due to indifferent attitude of superiors, mental strain (stress), negative approach of top management, and lack of job sharing. There is need for better communication between employees and their superiors. Family support is important in achieving work life balance.



Table-5 – Model Summary

Model	R	R square	adjusted r square	std. error of the estimate
4	.671d	.450	.445	7.46316

d. predictors: (constant), indifferent attitude of superiors, mental strain (stress), negative approach of top management, no sharing of job

Table-6 – ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
4	Regression	17340.520	4	4335.130	77.832	.000e
	Residual	21165.506	380	55.699		
	Total	38506.026	384			

e. Predictors: (Constant), indifferent attitude of superiors, mental strain (stress), negative approach of top management, no sharing of job

Table-7 – Coefficients

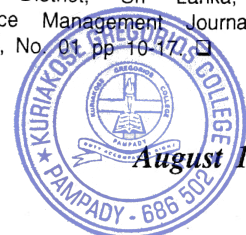
	Model	Model		Standardized Coefficients		Sig.
		B	Std. Error	Beta	t	
4	(Constant)	3.726	1.370		2.719	.007*
	Indifferent attitude of superiors	.196	.046	.252	4.310	.000*
	Mental strain (stress)	.459	.078	.289	5.924	.000*
	Negative approach of top management	.206	.039	.298	5.340	.000*
	No sharing of job	.221	.100	.099	2.216	.027*

a. Dependent Variable: family-life conflict

*Significant at 5 per cent level

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THIRD EYE : A JOURNAL OF BUSINESS REVIEW

A Refereed Journal of HPCMA & HPTU (Hamirpur)



Volume No.VI, No.VI, June 2019



ISSN:2319-3476

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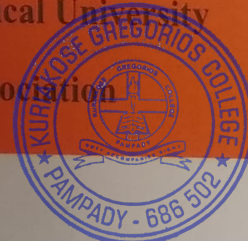
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Inter-dependence between Work-life Conflict and Family-life Conflict of the Bank Employees in Kerala

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Introduction

In this era of globalisation the boundaries of the world are disappearing, especially with respect to work. At present, global organizations are working 24 X 365. Everyone's focus is more on the work than the personal life, which is creating an imbalance between the professional work and the personal life. Work-life and personal life are two sides of life. In various work-life balance surveys, the majority of the employees said that they were not able to strike a balance between their personal and professional lives. They had to form robust selections, once their work and private life is obscurity were about to reach an equilibrium. Increasing work pressures, globalisation and technological advancements have made it an issue to all professionals working across all levels and all industries throughout the world. Achieving a level of work-family-life balance is not as easy as any other work.

Work-life balance is an important element in managing the work-family-life conflict of all employees. There is a conflict between the official life, personal life, family life and social life of all employees. In official life, the bank employees have problems related to customers' service, job, subordinates or colleagues, superiors and management, strain (stress), infrastructure, non-banking activities etc. Lack of career growth and development, physical strain, etc. are the problems faced by the employees in personal life. In family life, the employees face problems related to caring parents, child care, spouse support and day-to-day activities of the household. Unhealthy relationship with friends and relatives, and

nonparticipation in social activities are the problems faced by an employee in his social life. Every employee desires a balance between the official, personal, social and family life. A balance between these four elements create happiness and peace in the work – family-life of a person. The happiness, satisfaction and peace motivate the employee to work effectively. It reduces the employee burnout. The effective work of an employee helps the organisation to attain its goals. This study tries to describe the factors affecting the work-family-life conflict using collected data from selected 550 bank employees in Kerala using questionnaire. In this research paper, the demographic profile of the selected bank employees in Kerala and the mutual dependence between work-life and family-life conflict is presented.

Objective

The main objective of the paper is to identify the dependence between work-life conflict and family-life conflict.

Methodology

Primary data have been used for this study, which are collected from 550 selected employees with a well-designed questionnaire, the employees were selected by applying Two-stage random sampling method.

Tools

The collected data were analysed with appropriate statistical method such as simple linear regression model.

Demographic Profile of Bank employees

The profile of sample explaining the occupational features of bank employees is presented in the table given below.

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Table 1: Occupational profile of bank employees

	<i>Categories</i>	<i>Frequency</i>	<i>Percent</i>
<i>Type of bank</i>	<i>Public Sector</i>	300	54.5
	<i>Private Sector</i>	250	45.5
	<i>Total</i>	550	100
<i>Designation</i>	<i>Senior Manager</i>	120	21.8
	<i>Junior Manager</i>	195	35.5
	<i>Clerk cum cashier</i>	235	42.7
	<i>Total</i>	550	100
<i>Experience</i>	<i>below 5 years</i>	145	26.4
	<i>5-10</i>	174	31.6
	<i>10-15</i>	62	11.3
	<i>15-20</i>	38	6.9
	<i>20 & above</i>	131	23.8
	<i>Total</i>	550	100
<i>Location</i>	<i>Urban</i>	146	26.5
	<i>Semi urban</i>	366	66.6
	<i>Rural</i>	38	6.9
	<i>Total</i>	550	100
<i>Distance between Residence to branch</i>	<i>below 10 km</i>	250	45.5
	<i>10-20</i>	147	26.7
	<i>20 & above</i>	153	27.8
	<i>Total</i>	550	100
<i>Number of hours worked per day</i>	<i>7 hrs</i>	95	17.3
	<i>7-9</i>	240	43.6
	<i>above 9</i>	215	39.1
	<i>Total</i>	550	100
<i>No. of transfers in service</i>	<i>Nil</i>	54	9.8
	<i>1-2</i>	160	29.0
	<i>3-5</i>	200	36.4
	<i>6-7</i>	52	9.5
	<i>above 7</i>	84	15.3
	<i>Total</i>	550	100



Table 1 exhibits the profile of the sample respondents (employees) selected for the study. As per the Table, while 54.5 per cent of the respondents belong to Public sector banks, 45.5 per cent belong to private sector banks. Designation-wise classification shows that 42.7 per cent are clerks cum cashiers, 35.5 per cent are junior managers and 21.8 per cent are senior managers. Experience-wise classification depicts that 31.6 per cent of employees have 5-10 years of experience, 26.4 per cent have less than 5 years, 23.8 per cent have 20 and above years, 11.3 per cent have 10-15 years and 6.9 per cent have 15-20 years of experience in banking. It is observed that 66.6 per cent of the employees work in semi-urban branches, 26.5 per cent in urban branches and 6.9 per cent in rural branches. Distance from residence to branch-wise classification

indicates that 45.5 per cent stay within less than 10 km, 27.8 per cent within 20 km and above and 26.7 per cent within 10-20 km. Working hours-wise classification reveals that 43.6 per cent work 7-9 hours daily, 39.1 per cent work more than 9 hours, and 17.3 per cent work 7 hours. Number of transfer-wise classification shows that 36.4 per cent were transferred 3-5 times, 29.0 per cent were transferred 1-2 times, 15.3 per cent were transferred more than 7 times, and 9.5 per cent were transferred 6-7 times; 9.8 per cent were not yet transferred.

Impact of work-life conflict on family-life conflict
Work-life conflict creates family-life conflict. Here the effect of work-life conflict on family-life conflict is analysed with the help of simple linear regression model and the output is presented in Tables 2, 3 and 4.

Table 2 - Model Summary

<i>Model</i>	<i>R</i>	<i>R Square</i>	<i>Adjusted R Square</i>	<i>Std. Error of the Estimate</i>
1	.373 ^a	.139	.137	9.30149

b. Dependent Variable: family-life conflict

Source: Survey data

Table 3-ANOVA^a

<i>Model</i>		<i>Sum of Squares</i>	<i>df</i>	<i>Mean Square</i>	<i>F</i>	<i>Sig.</i>
1	<i>Regression</i>	5369.719	1	5369.719	62.065	.000 ^{b*}
	<i>Residual</i>	33136.307	383	86.518		
	<i>Total</i>	38506.026	384			

b. Predictors: (Constant), work-life conflict

Source: Survey data

* Significant at 5 per cent level



Table 4 - Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.547	1.498		7.042	.000*
	Work-life Conflict	.354	.045	.373	7.878	.000*

a. Dependent Variable: family-life conflict

Source: Survey data

* Significant at 5 per cent level

The effect of work-life conflict on family-life conflict was measured by using the simple linear regression model. The R² clearly indicated that 13.9 per cent of the variation of family life conflict was due to work-life conflict. The output indicated that the work-life conflict affected the family life conflict, as the beta coefficient and its associated t value were found significant (Beta co-efficient .354 and t value 7.878 with P < .05). So,

it could be concluded that work-life conflict created family-life conflict among the employees of banks.

Impact of family-life conflict on work-life conflict

Family-life conflict creates work-life conflict. Here the effect of family-life conflict on work-life conflict is analysed with the help of simple linear regression model and the output is presented in Tables 5, 6 and 7.

Table 5 - Model Summary

Model	R	R Square	Adjusted R	Std. Error of the
1	.373 ^a	.139	.137	9.81884

b. Dependent Variable: work-life conflict

Source: Survey data

Table 6 - ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5983.655	1	5983.655	62.065	.000 ^{b*}
	Residual	36924.880	383	96.410		
	Total	42908.535	384			

b. Predictors: (Constant), family-life conflict

Source: Survey data

* Significant at 5 per cent level

Table 7-Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	23.072	1.197		19.268	.000*
	Family-life conflict	.394	.050	.373	7.878	.000*

a. Dependent Variable: work-life conflict

Source: Survey data

* Significant at 5 per cent level



The effect of family-life conflict on work-life conflict was measured by using simple linear regression model. The R^2 clearly indicated that 13.9 per cent of the variation of work-life conflict was due to the effect of family-life conflict. The output indicated that the family-life conflict affected the work-life conflict, as the beta co-efficient and its associated t value were found significant (Beta co-efficient .394 and t value 7.878 with $P < .05$). So, it could be concluded that family-life conflict create work-life conflict among the employees of banks.

Findings

1. More than half of the employees work in Public sector banks and around half of the employees belong to private sector banks. 2/5th of the employees are clerk cum cashiers and 1/3rd are junior managers. Around 1/3rd of the employees have experience of 5-10 years and 1/4th are new entrants. 2/3rd employees working in semi urban branches and 1/4th are in urban branches. Nearly half of the employees stayed within less than 10 km distance. 2/5th of the employees working 7-9 hours and another 2/5th working over 9 hours. 1/3rd of employees transferred 3-5 times and nearly 3/10th transferred 1-2 times.
2. The impact of work-life conflict on family-life conflict was examined by using simple linear regression model. 13.9 per cent of the variation of family-life conflict was due to the effect of work-life conflict. The output pointed out that the work-life conflict affected the family-life conflict, as the beta co-efficient and its associated t value were found significant (Beta co-efficient .354 and t value 7.878 with $P < .05$). So, it could be concluded that work-life conflict created family-life conflict among the employees of banks.
3. The impact of family-life conflict on work-life conflict was identified by applying simple linear regression model. 13.9 per cent of the variation of work-life conflict was due to the effect of family-life conflict. The output indicated that the family-life conflict affected the work-life conflict, as the beta co-efficient and its associated t value were significant (Beta co-efficient .394 and t value 7.878 with $P < .05$). So, it could be concluded that family-life conflict created work-life conflict among the employees of banks.

Conclusion

In this research paper the work-life balance of public and private sector bank employees has been under

study. Here, the dependence between the work-life conflict and family-life conflict of the employees are identified. Work-life conflict created family-life conflict among the employees of banks and vice-versa.

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