

Final Project Report of the Work Done on the Project Entitled “Development of Composite Nanofibers Electrospinning for Photonic Applications”

1. Project Title	DEVELOPMENT OF COMPOSITE NANOFIBERS BY ELECTROSPINNING FOR PHOTONIC APPLICATIONS
2. NAME AND ADDRESS OF THE PRINCIPAL INVESTIGATOR	DR. SAJEEV US ASSISTANT PROFESSOR DEPARTMENT OF PHYSICS GOVERNMENT COLLEGE KOTTAYAM NATTAKOM PO KOTTAYAM-686013
3. NAME AND ADDRESS OF THE INSTITUTION	GOVERNMENT COLLEGE KOTTAYAM NATTAKOM PO KOTTAYAM - 686013
4. UGC APPROVAL LETTER NO. AND DATE	F.NO 41-895/2012(SR) DATED 23/07/2012
5. DATE OF IMPLEMENTATION	1/07/2012
6. TENURE OF THE PROJECT	3 YEARS
7. TOTAL GRANT ALLOCATED	Rs. 12,37,129/- (Rupees Twelve lakhs ninety thousand and seven hundred only)
8. TOTAL GRANT RECEIVED	First instalment :- 9,42,200/- (Nine lakhs forty two thousand two hundred only) Second Instalment :- 2,30,586 (Two lakhs thirty thousand five hundred and eighty six only) Total Grant received :- 11,72,786/- (Eleven lakhs seventy two thousand seven hundred and eight six only)
9. FINAL EXPENDITURE	Rs 12,52,544.05/- (Twelve lakh fifty two thousand five hundred and forty four rupees and five paisa only)
10. TITLE OF THE PROJECT	DEVELOPMENT OF COMPOSITE NANOFIBERS BY ELECTROSPINNING FOR PHOTONIC APPLICATIONS
11. OBJECTIVES OF THE PROJECT	THE OBJECTIVE OF THE PROPOSED WORK IS THE DEVELOPMENT OF ORGANIC-INORGANIC COMPOSITE NANOFIBERS. IT INCLUDES 1. SYNTHESIS OF 1D NANOSTRUCTURE OF PPV, PANI, PPY BY ELECTROSPINNING. CONTROL OVER THE PARAMETERS SUCH AS SPINNABILITY, FIBRE DIAMETER AND MORPHOLOGY OF THESE STRUCTURES BY THE INCORPORATION OF BINDERS LIKE POLY ETHYLENE OXIDE (PEO) OR POLY VINYL ALCOHOL (PVA). 2. INCORPORATION OF ZNO & ZNS, QDS OF APPROPRIATE SIZE SCALE INTO THE POLYMER MATRIX. 3. FABRICATION OF ONE DIMENSIONAL COMPOSITE STRUCTURE DIRECTLY FROM THE COMPOSITE MATRIX BY

	<p>ELECTROSPINNING.</p> <p>4.STRUCTURAL CHARACTERISATION OF POLYMER/POLYMER COMPOSITE MATERIALS USING, SEM, TEM, UV-VIS,XRD AND FTIR</p> <p>5. STUDY OF ELECTROLUMINESCENCE, PHOTO LUMINESCENCE, THERMAL STABILITY AND J-V CHARACTERISTICS (PHOTO CONDUCTIVITY AND DARK CONDUCTIVITY) TO ASSESS THE APPLICATION POTENTIAL OF THE MATERIAL.</p>
<p>12. WHETHER OBJECTIVES WERE ACHIEVED</p>	<p>YES</p> <p>POLYMER NANOFIBERS AND MEMBRANES OF FOLLOWING POLYMERS WERE PREPARED SUCCESSFULLY. (DETAILS ATTACHED SEPERATELY)</p> <ol style="list-style-type: none"> 1. POLYSTYRENE 2. POLYMETHYL METHACRYLATE 3. POLYVINYL PYRROLIDONE 4. POLYVINYL ALCOHOL 5. POLYCAPROLACTONE 6. CHITOSAN 7. POLYANILINE <p>These polymers were used for synthesising nano/micro fibers. Fiber structures having different morphologies and properties were successfully prepared. We were able to optimize the preparation conditions for these fibers, which has repeatability. All our works followed a general routine viz, synthesis, followed by characterization and analysis.</p> <p>Incorporation of the following quantum dots and dyes were successfully done</p> <p>Dyes</p> <ol style="list-style-type: none"> 1. Rhodamine -B 2. Curcumin 3. Alizarin 4. Crystal Violet 5. Rose Bengal <p>Quantum Dots(QDs)</p> <ol style="list-style-type: none"> 1. Manganese doped Zinc Sulphide (MnZnS) 2. Silver Nanoparticles (Ag) 3. Titanium Dioxide(TiO₂) <p>We were able to incorporate these quantum dots and dyes into the polymer matrices and thereby impart optical, electrical and antibacterial properties to them. The composite (polymer + dyes / quantum dots) were successfully electrospun to form structures like nanofibers, micro fibers and membranes. Incorporation of dyes and QDs mainly imparted fluorescence to the synthesized structures which made them suitable for laser, waveguiding and sensor applications. Device implementation requires intimate collaboration with industrial researchers.</p>

<p>13. ACHIEVEMENTS FROM THE PROJECT</p>	<p>The following Papers and Seminar Presentations came out from the project.</p> <ol style="list-style-type: none"> 1. <i>Preparation of One Dimensional Nanostructure by Electrospinning</i> Parvathy Radhakrishnan, Sajeew U S, Department of Physics, Government College Nattakom, Kottayam - 686013 New Numbers And Letters, An Interdisciplinary Research Journal, Volume 4 Issue 1 December 2013, ISSN 2320-8317. 2. <i>Development of biopolymer membranes and analysis of pore size distribution using scanning electron microscopy</i> Parvathy Radhakrishnan, K T Nasla Mariam, N A Aswathy & U S Sajeew, "Current Trends In The Fields Of Nano Science And Nanotechnology", UGC sponsored National Seminar in collaboration with DREAM LAB, Department of Physics, CUSAT. Conducted by KKTU Government College, Pullut, Kodungalloor. 3. <i>A Study on the Optical Properties of Dye Doped Polycaprolactone Microstructures</i> Krishnakumar G, Parvathy Radhakrishnan, E I Anila, U S Sajeew Aquinas Journal of Multidisciplinary Research Studies Volume 1 Issue 1. 4. <i>The Effect of Polymer Degradation in the Formation of Nano/Micro Structure of Polycaprolactone</i> Nithish Mankuzhiyil David, Sonamol Mathew, Parvathy Radhakrishnan, Krishnakumar G, E I Anila, K S Sreelatha, Jacob K Chacko, Tomlal Jose E, U S Sajeew "National Conference on Advances in Crystal Growth and Nanotechnology", CMS College, Kottayam. 5. <i>Study on Optical Properties of Dye Doped PS Microfibers</i> Krishnakumar G, Parvathy Radhakrishnan, E I Anila, U S Sajeew, K S Sreelatha "National Seminar on Advanced Materials for Energy and Environment NSMEE 2015", Vimala College, Thrissur. 6. <i>Structural and Photoluminescence Characterization of Dye Doped Polymethylmethacrylate Microfibers</i> Parvathy R, Krishnakumar G, Anila E I, Sajeew U S "National Conference on Innovative Engineering (NCIE 2015)" on 19th March 2015 organised by Holy Grace Academy of Engineering, Mala, Thrissur, Kerala. Paper published on International Journal of Advanced Research Trends in Engineering and Technology (IJARTET) ISSN 2394-3777(Print) ISSN 2394-3784(Online). Impact Factor - 1.002; Volume 2, Issue 3 March 2015 (Best paper Award)
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7. *Studies on One Dimensional Composite Nanostructures* 'Manu Madhu, Jyothish P P, K S Sreelatha, E I Anila, **Sajeev U S**; Organised by SreeSankaraVidyapeetom, Valayanchirangara, Perumbavoor
(Best paper Award)
8. *'Dye Doped Polycaprolactone Microstructure: A Promising Material For Photonic Applications'* Arya Gopinathan Nair, Vini T Ravindran, Krishnakumar G, *ParvathyRadhakrishnan*, SajeevSivaraman, UGC sponsored National seminar entitled "Current Trends in Material Science" organized by the Physics Department of Aquinas College, Edacochin, Kerala.
9. *'Studies on ElectrospunPolymethyl Methacrylate (PMMA) Micro Structures'*Nyji Wilson, Divya. N, Krishnakumar G, ParvathyRadhakrishnan, U S Sajeev, UGC sponsored National Seminar on"Emerging Trends in Nanomaterials" on 9th and 10th July 2015 organized by the Department of Chemistry,SreeSankaraVidyapeetomCollege, Valayanchirangara
10. *'Particle Size Control of Silver Nanoparticles Using Polyvinylpyrrolidone'*KanthiThankachan, V S Krishnapriya, G Krishnakumar, ParvathyRadhakrishnan, K S Sreelatha, U S Sajeev*,UGC sponsored National Seminar on "Emerging Trends in Nanomaterials" on 9th and 10th July 2015 organized bythe Department of Chemistry, SreeSankaraVidyapeetom College, Valayanchirangara.
11. *'Removal of Metallic Nanoparticles From Drinking Water Using Bentonite- Silver Nitrate System As A Prototype'*Merin Mary Mohan, Salini S Kumar, Krishnakumar G, ParvathyRadhakrishnan S Sajeev *, K S Sreelatha, UGC sponsored National seminar on "Trends in Physical Science-TriPS-2015" organized by the of Physics, SreeSankara College, Kalady, Kerala.

The following MSc Projects were done as a part of this Project

1. ***"RHODAMINE INCORPORATED CHITOSAN MEMBRANE"***
BY
ANJALI M & KRISHNENDU CC
DEPARTMENT OF PHYSICS
ST. STEPHENS COLLEGE UZHAVOOR
2. ***"DEVELOPMENT OF CHITOSAN MEMBRANE WITH SILVER NANOPARTICLES"***
BY
SHANISH .K & BIBIN RAJU
BASELIUS COLLEGE KOTTAYAM

	<p>3. <i>"A STUDY ON DYE DOPED POLYCAPROLACTONE MICRO STRUCTURES"</i> BY ARYA.G .NAIR & VINI T R Government College Kottayam</p> <p>4. <i>"DEVELOPMENT OF QUANTUM DOTS INCORPORATED ONE DIMENSIONAL POLYMER NANO STRUCTURES"</i> BY MANU MADHU, GOVERNEMNT COLLEGE KOTTAYAM JYOTHISH P, GOVERNEMENT COLLEGE KOTTAYAM</p> <p>5. <i>"STUDIES ON DYE DOPED POLYSTYRENE MICRO FIBERS"</i> BY VIDYA PV , ATHIRA C R , VEENA VENU K.G COLLEGE PAMPADY</p> <p>6. <i>"THE EFFECT OF POLYMER DEGRADATION IN THE FORAMTION OF NANO/MICRO STRUCTURE BASED ON BIOPOLYMER-POLYCARPOLATONE"</i> BY NITHISH MANKUZHIYIL DAVID & SONAMOL MATHEW BASELIUS COLLEGE KOTTAYAM</p> <p>7. <i>"PARTICLE SIZE CONTROL OF SILVER NANO PARTICLE USING POLYVINYL PYRROLIDONE"</i> BY KANTHI THANKACHAN & KRISHNAPRIYA V S GOVERNMENT COLLEGE KOTTAYAM</p> <p>8. <i>"POLYANILINE BASED CONDUCTING POLYMER CHEMICAL SENSOR"</i> BY JIBIN THOMAS, ST STEPHENS COLLEGE UZHAVOOR</p> <p>9. <i>"REMOVAL OF METALLIC NANOPARTICLES FROM DRINKING WATER USING BENTONITE SILVER NANO PARTICLE SYSTEM AS A PROTOTYPE"</i> BY MERIN MARY MOHAN & SALINI S KUMAR MARTHOMA COLLEGE THIRUVALLA</p> <p>10. <i>"STUDIES ON ELECTROSPUN POLYMETHYL METHACRYLATE (PMMA) MICRO STRUCTURES"</i> BY NYJI WILSON C & DIVYA N BASELIUS COLLEGE KOTTAYAM</p> <p>11. <i>"DEVELOPMENT OF COMPOSITE THIN FILM BY ELECTROSPINNING "</i> BY GAYATHRI KRISHNAN & ARYA P BABU N.S .S COLLEGE CHANGANACHERRY</p>
<p>14. SUMMARY OF FINDINGS</p>	<p>In summary, Electrospinning process was found to be an efficient method for the production of uniform and aligned fibers for a polymer solution of appropriate concentration. The prepared micro/nano fibers/structures have established its applicability for waveguiding, sensing and various biomedical applications. Different structures such as porous fibers, beaded fibers, aligned and non-aligned fibers are formed by changing Electrospinning conditions and for various concentrations. Morphology of the structures is analysed using Scanning Electron Microscopy (SEM) analysis. Chemical structure is studied using Fourier Transform Infrared spectroscopy (FTIR). Optical properties of these structures formed are</p>

	<p>studied using UV-Vis-NIR and Photoluminescence spectroscopy. The following are the findings from various works done under this project;</p> <ul style="list-style-type: none"> • In the study of homogenous incorporation of AgNPs into chitosan membranes had carried out and the structural and optical properties were analysed. It was found that the fluorescence spectra of chitosan strongly modified when AgNPs are incorporated. By fluorescence spectroscopy the energy levels of these materials are determined. The prepared membranes are potential candidates in biomedical field. • The comparison of non-degraded and degraded nano/micro PCL had carried out and structural and optical properties of these structures were analysed. It is found that the preparation using non-degraded PCL resulted in fiber structures and degraded PCL resulted in the formation of polymer films. The degradation was reflected in the photonic structure of the material • Silver NPs and Rhodamine B are incorporated into the PVA membrane in a study. The structural and optical properties of these structures were analysed. It was found that the fluorescence spectra of PVA got strongly modified when AgNPs and Rhodamine B were incorporated. The structural analysis of the PVA-AgNPs system showed that the chemical structure was modified. This modification reflected in the photonic structure of the material. Incorporation of AgNPs and Rhodamine B were successfully carried out into PVA membranes by precipitating AgNPs in aqueous solution. Rhodamine B was added in an optimized concentration into the PVA solution. By UV-Vis spectroscopy the presence of excitonic levels created between the energy gaps of PVA were detected. By the population of empty optical levels in PVA matrix, it was possible to turn this as a material showing non-linear optical properties as well as optical switching properties • We have incorporated Rhodamine B into PCL micron sized fibers at different concentrations (5 different concentrations of Rhodamine B were taken). The SEM, FTIR studies of the composites had been taken to study the morphology and chemical composition of the photonic active polymer fibers. The polymer fiber for different concentration was subjected to fluorescence spectroscopy. The emission and absorption properties at different wavelengths for these samples were analysed. It was found that the fluorescence property of the nano/micro fibers has great dependence on the concentration of the dye. It was also found that some excitonic peaks are obtained due to the incorporation of Rhodamine B into the polymer fiber
<p>15. CONTRIBUTION TO THE SOCIETY</p>	<p>Polymer micro/nano fibers prepared by Electrospinning can be used for micromanipulation of light. Wavelength-converted-waveguiding was achieved by doping suitable dye dopants into the polymer matrix. They exhibited interesting optical and structural properties. These investigations gave way to miniaturised lasers in many</p>

	<p>photonic devices.</p>
<p>16. WHETHER ANY PHD ENROLLED/PRODUCED OUT OF THE PROJECT</p>	<p>YES Name of the scholar: Parvathy Radhakrishnan Name of the University: Mahatma Gandhi University, Kottayam, Kerala Registration Order No. & Date: U O No. 264/2014/AII/3/Academic. Dated : 10/01/2014 Title of research work: ‘Study on the Photonic Properties of One Dimensional Nanostructures’ Name of the Institution & Department: Department of Physics, Union Christian College, Aluva. Whether full-time/part-time: Full-time Name & Address of supervising teacher: Dr E I Anila, Associate Professor, Department of Physics, U C College , Aluva</p>
<p>17. NO. OF PUBLICATIONS OUT OF THE PROJECT</p>	<p>4 +1(Communicated)</p> <ol style="list-style-type: none"> 1. <i>Structural and Photoluminescence Characterization of Dye Doped Polymethylmethacrylate Microfibers</i> Parvathy R, Krishnakumar G, Anila E I, Sajeev U S “National Conference on Innovative Engineering (NCIE 2015)” on 19th March 2015 organised by Holy Grace Academy of Engineering, Mala, Thrissur, Kerala. Paper published on International Journal of Advanced Research Trends in Engineering and Technology (IJARTET) ISSN 2394-3777(Print) ISSN 2394-3784(Online). <i>(Best paper Award)</i> 2. <i>The Effect of Polymer Degradation in the Formation of Nano/Micro Structure of Polycaprolactone</i> NithishMankuzhiyil David, Sonamol Mathew, Parvathy Radhakrishnan, Krishnakumar G, E I Anila , K S Sreelatha, Jacob K Chacko, Tomlal Jose E, U S Sajeev“National Conference on Advances in Crystal Growth and Nanotechnology”, CMS College, Kottayam. ISBN 978-81-925991-8-2 3. <i>‘A Study on the Optical Properties of Dye Doped Polycaprolactone Microstructures’</i> KrishnakumarG,Parvathy Radhakrishnan, E I Anila, U S Sajeev Aquinas Journal of Multidisciplinary Research StudiesVolume1;ISSN 2395-7751. 4. <i>Preparation of One Dimensional Nanostructure by Electrospinning</i> Parvathy Radhakrishnan, Sajeev U S, Department of Physics, Government College Nattakom, Kottayam - 686013 New Numbers And Letters, An Interdisciplinary Research Journal, Volume 4 Issue 1 December 2013, ISSN 2320-8317. 5. <i>‘Emission Wavelength Tuning of Dye Doped Polymethylmethacrylate Microfibers’</i> Parvathy R, Krishnakumar G, Anila E I, Sreelatha K S, Sajeev U S. <i>(Communicated to Polymer Bulletin, manuscript no. POBU-D-16-00314, Springer)</i>

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