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CERTIFICATE

This is to certify that the thesis entitled ***"SYNTHETIC APPROACHES, CHARACTERIZATION AND APPLICATIONS OF CONDUCTING POLYTHIOPHENE-MWCNT NANOCOMPOSITES"*** is an authentic record of research work carried out by **Ms. SWATHY T S** under my supervision in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Chemistry of University of Calicut and further that no part thereof has been presented before for any other degree.

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DECLARATION

I hereby declare that the thesis entitled ***"SYNTHETIC APPROACHES, CHARACTERIZATION AND APPLICATIONS OF CONDUCTING POLYTHIOPHENE-MWCNT NANOCOMPOSITES"****, submitted to the University of Calicut in partial fulfillment of the requirement for the award of the Degree of Doctor of Philosophy in Chemistry is a bonafied research work done by me under the supervision of* ***Dr.JINISH ANTONY M****, Assistant Professor, Research and Post graduate Department of Chemistry, St.Thomas College (Autonomous), Thrissur.*

I also declare that the material presented in this thesis is original and does not form the basis for the award of any other degree, diploma or other similar titles of any other university.

Swathy

Date: 05/06/2023

SWATHY T S

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With heartfelt gratitude

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Dedicated to

My Parents

Preface

Conducting polymers are promising materials in different research such as medicinal, technological, and industrial fields. Conducting polymers are used alone or in combination with other attractive materials in different applications. Among the conducting polymers, polythiophenes are very attractive for their peculiar properties such as good environmental stability, optical properties, mechanical properties, and electrical conductivity. Polythiophene nanocomposites with conducting carbon nanomaterials are promising for the possibility for achieving enhancement in various properties related to it including the enhancement in electrical conductivity. One dimensional carbon nanotubes exhibiting unique mechanical, optical, thermal, and electrical properties would be a great combination for polythiophene on nanocomposites formation.

In this work, study on different synthetic approaches of polythiophene-multiwalled carbon nanotube nanocomposites, its characterization and applications were carried out. Water soluble/dispersible nature of nanocomposites is an attractive property which promises its further processability in future applications in an easy way. Unsubstituted polythiophene are water insoluble or non-dispersible in nature. Preparation of nanocomposites with suitable fillers is one of the ways to improve processability of polythiophene materials. Unsubstituted polythiophene-carbon nanotube nanocomposites were prepared by effective in-situ chemical oxidative polymerization of thiophene monomer. Achievement of attractive morphology of nanocomposites is another factor to be considered in the preparation of nanocomposites. Influence of double tail anionic surfactant AOT were identified as helping for attaining superior morphology, good processability and other properties, which is discussed in chapter 2. Another way of preparing processable and superior polythiophene carbon nanotube nanocomposites is utilizing functionalized carbon nanotubes in nanocomposites preparation. Functionalization of carbon nanotubes improves the processability by decreasing its inherent self-bundling property. Nanocomposites preparation of polythiophene with functionalized carbon nanotubes and their characterization were described in chapter 3.

Functionalized carbon nanotube-polythiophene binary nanocomposites exhibited good aqueous dispersion and further lead to preparation of higher order

ternary nanocomposites of polythiophene-functionalized multiwalled carbon nanotube with silver nanoparticles, which is discussed in chapter 4. Studies on the superior thermal and electrical properties of silver nanocomposites were also discussed in chapter 4. An elaborative study of catalytic and antibacterial properties of the prepared silver nanocomposites were presented in chapter 5. The high catalytic activity of silver nanocomposites in the model p-nitrophenol reduction reaction, its mechanism and superior antibacterial action is described in chapter 5. The study on catalytic decolourization of azo compounds were conducted with mechanistic point of view conducted in chapter 6.

Utilization of soluble polythiophene derivatives is another way of improving processable nature nanocomposites in future applications. Chapter 7 describes a simple physical mixing approach of nanocomposites preparation using substituted polythiophene, poly(3-thiophene ethanol) with functionalized multiwalled carbon nanotubes. The prepared nanocomposites exhibited stable dispersion in ethanol. The electrical and electrochemical properties of poly(3-thiophene ethanol)-functionalized multiwalled carbon nanotube nanocomposites were demonstrated as efficient electrode material in supercapacitor applications.

Abbreviations

PT	Polythiophene
CNT	Carbon nanotubes
AOT	Sodium bis(2-ethyl hexyl) sulfosuccinate
MWCNT	Multiwalled carbon nanotube
MWCNT-COOH	Functionalized multiwalled carbon nanotube
FT-IR	Fourier transform infrared
WXRD	Wide angle X-ray diffraction
EDX	Energy dispersive X-ray analysis
XPS	X-ray photoelectron spectroscopy
SEM	Scanning electron microscopy
FE-SEM	Field emission scanning electron microscopy
TEM	Transmission electron microscopy
TGA	Thermogravimetric analysis
UV-vis	Ultraviolet-visible
Ag NPs	Silver nanoparticles
P-NP	p-Nitrophenol
E. coli	Escherichia coli
AB	Azobenzene
HR-MS	High resolution mass spectroscopy
NMR	Nuclear magnetic resonance
PTE	Poly(3-thiophene ethanol)
CV	Cyclic voltammetry
GCD	Galvanostatic charge discharge