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Research Papers

Manganese (III) oxide-infused poly(thiophene-*co*-pyrrole) nanocomposites for optical, dielectric, and photocatalytic applications

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ARTICLE INFO

Keywords:
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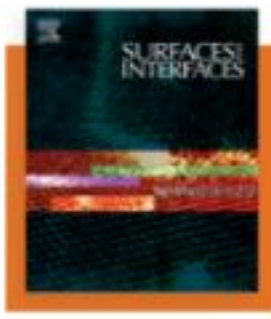
ABSTRACT

Copolymer nanocomposites consisting of poly(thiophene-co-pyrrole) (PTh-co-PPy) and manganese (III) oxide (Mn_2O_3) nanofillers were synthesized via in-situ polymerization. FTIR confirmed the interfacial interactions between Mn_2O_3 and the copolymer. UV-vis spectra revealed that the 5 wt % Mn_2O_3 nanocomposites exhibited the highest absorption and refractive index, along with the lowest optical bandgap, indicating effective integration. PL spectra showed fluorescence quenching and red shift, indicating strong interfacial interactions and optoelectronic potential. XRD confirmed crystalline growth of Mn_2O_3 in the copolymer, while FE-SEM and HR-TEM showed uniform dispersion of raspberry-like nanoparticles. DSC and TGA demonstrated an increased glass transition temperature and enhanced thermal stability. Electrical measurements revealed enhanced dielectric constant, electric modulus, and conductivity up to 5 wt % Mn_2O_3, followed by a decline at higher nanofiller concentrations. Photocatalytic activity with methylene blue confirmed maximum degradation efficiency for the 5 wt % nanocomposite. These findings highlight the promise of Mn_2O_3-reinforced PTh-co-PPy nanocomposites in optoelectronic and environmental applications.

S. Sankar and **M.T. Ramesan,** "Manganese (III) Oxide-Infused Poly(thiophene-co-pyrrole) Nanocomposites for Optical, Photocatalytic, and Dielectric Applications" **Materials Research Bulletin**, 193, 113649, 2026. https://doi.org/10.1016/j.materresbull.2025.113649



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Tunable optical, electrical, and gas-sensing properties of poly (thiophene-*co*-indole)/CuO nanocomposites

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ARTICLE INFO

Keywords:
Copolymer
Poly (thiophene-co-indole)
CuO nanoparticles
Optical properties
AC conductivity
Ammonia gas sensing

ABSTRACT

Nanocomposites of conducting copolymers possess exceptional chemical and physical characteristics that make them a strong candidate for developing gas sensors and optoelectronic devices, both of which are crucial for environmental monitoring and applications needing sophisticated optoelectrical performance. Here, poly (thiophene-co-indole) reinforced with varying doses of copper oxide nanoparticles (PPCuO) were synthesized through an in-situ polymerization to enhance its optical, electrical, thermal and gas sensing capabilities. XRD and FTIR analysis verified the successful formation of nanocomposites and their molecular interactions. UV–Vis spectroscopy exhibited a significant enhancement in absorption with CuO loading up to 7 wt%, where PPCuO7 exhibited the lowest bandgap energy and highest refractive index, indicating strong potential for optoelectronic applications. Morphological observation revealed homogeneous nanoparticle dispersion in PPCuO7, however, higher loadings resulted in aggregation and reduced polymer-filler interactions. Thermal studies (TGA and DSC) indicated superior thermal stability and enhanced phase transition temperature with increasing CuO loadings. The dielectric properties and conductivity improved with filler loading, attributed to the development of a more

R. Gopika and **M. T. Ramesan,** "Tunable Optical, Electrical, and Gas-Sensing Properties of Poly(thiophene-co-indole)/CuO Nanocomposites" **Surfaces and Interfaces,** 73, 107547, 2025.
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RESEARCH

Versatile functional properties of polyindole/CuO nanocomposites for dielectric and environmental sensing applications

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Received: 28 July 2025 / Accepted: 25 August 2025

Abstract
Conductive polyindole/copper oxide (PInCuO) nanocomposites (NCs) were synthesized via oxidative in situ polymerization. Fourier-transform infrared spectroscopy (FT-IR) and X-ray diffraction (XRD) analyses confirmed the successful incorporation of CuO nanoparticles and their crystallinity within the polymer matrix. UV–Vis analysis revealed enhanced optical conductivity, a reduced optical bandgap, and an increased refractive index with CuO addition, showing optimal effects at 7 wt% loading. Field-emission scanning electron microscopy (FE-SEM) images revealed a uniform nanoparticle dispersion at this concentration, whereas higher loadings led to agglomeration. Differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA) revealed that the incorporation of CuO significantly improved the phase transition temperature and thermal stability of the NCs. The impact of nanofiller concentration, frequency, and temperature on the electrical, dielectric, and modulus properties was systematically investigated. Dielectric analysis showed a substantial increase in the dielectric constant with increasing filler content, with the NC containing 7 wt% CuO (PInCuO7) exhibiting the highest charge storage capacity. Moreover, PInCuO7 exhibited the highest AC conductivity of 3.5×10^{-5} S/cm at room temperature and 10^6 Hz, significantly surpassing that of pristine PIn (2.7×10^{-6} S/cm). The activation energy from Arrhenius plots was significantly lower for PInCuO7 (0.054 eV) compared to PIn (0.174 eV), indicating enhanced charge carrier mobility due to the effective dispersion of CuO. Additionally, PInCuO NCs exhibited improved ammonia sensing

R. Gopika and **M. T. Ramesan,** "Versatile Functional Properties of Polyindole/CuO Nanocomposites for Dielectric and Environmental Sensing Applications" **Microchimica Acta,** 192, 683, 2025. https://doi.org/10.1007/s00604-025-07527-w

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Chitosan-functionalized poly(thiophene-co-pyrrole) nanocomposites: promising materials for optoelectronics and antibacterial surfaces

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ARTICLE INFO

Keywords:
Poly(thiophene-co-pyrrole)
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Dielectric properties
Antibacterial

ABSTRACT

In this study, conductive copolymer nanocomposites of poly(thiophene-co-pyrrole) (PTh-co-PPy), reinforced with chitosan (Cs) nanofillers, were synthesized and characterized using a range of analytical techniques. Fourier-transform infrared (FT-IR) spectroscopy confirmed the incorporation of Cs nanofillers into the PTh-co-PPy matrix, indicating strong interfacial interactions. Ultraviolet-visible (UV-Vis) spectroscopy revealed shifts in absorption edges, increased refractive index, and reduced bandgap energy. The fluorescent emission spectrum showed enhanced intensity with Cs reinforcement, indicating efficient interaction between the polar entities of PTh-co-PPy and the Cs nanofillers. X-ray diffraction (XRD) analysis revealed enhanced long-range order in the nanocomposite (NC). Field emission scanning electron microscopy (FE-SEM) and high-resolution transmission electron microscopy (HR-TEM) demonstrated uniform dispersion of Cs nanoparticles at optimal loading (5 wt%), with clustering observed at higher concentrations (7 wt%). Thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) confirmed that the nanocomposites (NCs) exhibited superior thermal stability and a higher glass transition temperature than the pure copolymer, indicating enhanced resistance to thermal degra-

S. Sankar, TP Krishnaraj, P. Sunojkumar and **M. T. Ramesan,** "Chitosan-Functionalized Poly(thiophene-co-pyrrole) Nanocomposites: Promising Materials for Optoelectronics and Antibacterial Surfaces" **Journal of Molecular Liquids,** 437, 128319, 2025. https://doi.org/10.1016/j.molliq.2025.128319

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Cashew gum/boehmite bio-nanocomposite films: A promising platform for flexible Nano-dielectric devices

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ARTICLE INFO

Keywords:
Biopolymer
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Boehmite
Tensile strength
Dielectric constant
AC conductivity

ABSTRACT

This work focused on fabricating bio-nanocomposite films from cashew gum (CG) and boehmite (BHM) using a water-based solution casting technique, followed by comprehensive characterization through various analytical techniques. XRD and FTIR analyses confirmed the presence of characteristic BHM peaks and its successful integration into the CG matrix. Tauc's plot revealed a decreasing optical bandgap with increasing BHM content, likely due to the introduction of new energy states and structural changes in the CG matrix. FE-SEM and HR-TEM revealed significant morphological changes in the composites, indicating effective dispersion and interaction between CG and BHM. The thermal stability of CG improves with increasing BHM nanoparticle loading. Mechanical testing showed a 47 % increase in tensile strength for the CG/5 wt% BHM film, with only a slight reduction in elongation at break. Electrical properties, including AC conductivity, dielectric constant, loss tangent, electric modulus, and impedance were evaluated across various frequencies and temperatures. AC conductivity increased with frequency, while dielectric constant and loss tangent decreased. Furthermore, the electrical parameters increased with temperature and were strongly influenced by the BHM content. Notably, the CG/5 wt% BHM nanocomposite exhibited the highest conductivity and dielectric constant at ambient temper-

K. Meera and **M.T. Ramesan,** "Cashew Gum/Boehmite Bio-Nanocomposite Films: A Promising Platform for Flexible Nano-Dielectric Devices" **International Journal of Biological Macromolecules,** 318, 144985, 2025. https://doi.org/10.1016/j.ijbiomac.2025.144985

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Impact of nanocurcumin on mechanical, optical and electrical properties of chitosan/polyvinyl alcohol blend nanocomposites for sustainable applications

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ARTICLE INFO

Keywords:
Chitosan
Polyvinyl alcohol
Nanocurcumin
AC conductivity
Dielectric constant
Tensile strength

ABSTRACT

Blend nanocomposites of chitosan (CS) and polyvinyl alcohol (PVA), reinforced with varying concentrations of nanocurcumin (NC), were synthesized using a simple green method. The impact of NC on the optical, structural, and morphological characteristics of the blend nanocomposite films was evaluated through different analytical techniques, including FT-IR, XRD, UV–Vis spectroscopy, scanning electron microscopy, TGA, universal testing machine and electrical measurements. The distinctive peaks observed in the FT-IR and XRD analysis confirmed the successful incorporation of NC into the PVA/CS (PC) blend matrix. UV spectroscopy revealed that absorption increased with nanoparticle concentration, with the 9 wt% sample showing the highest intensity, which correlates with its low optical bandgap energy. SEM analysis showed that nanoparticles influenced the surface morphology of the PC matrix, with the most uniform particle distribution observed in the 9 wt% sample. Increasing NC content improved the thermal stability of the PC films. The nanocomposite with 9 wt% NC exhibited a significant improvement in tensile strength, increasing by 35 % compared to neat PC, along with an

M.T. Ramesan, R. Gopika, T. T. Khaleelul Rahman, K. T. Jamsheena and B. K. Bahuleyan, "Impact of Nanocurcumin on Mechanical, Optical and Electrical Properties of Chitosan/Polyvinyl Alcohol Blend Nanocomposites for Sustainable Applications" **International Journal of Biological Macromolecules** 309, 142976, 2025. https://doi.org/10.1016/j.ijbiomac.2025.142976

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Modulating the properties of carboxymethyl chitosan/polyethylene oxide nanocomposites with aluminium oxy hydroxide: A comprehensive study

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ARTICLE INFO

Keywords:
Carboxymethyl chitosan
Polyethylene oxide
γ-AlOOH, AC conductivity, dielectric constant
Nyquist plot

ABSTRACT

This study explores the eco-friendly synthesis of carboxymethyl chitosan/polyethylene oxide/γ-aluminium oxyhydroxide (CMCS/PEO/γ-AlOOH) nanocomposite films through a sustainable, green preparation method. The CMCS/PEO/γ-AlOOH nanocomposites were characterized through X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR) and scanning electron microscopy (SEM) to analyze their structural and morphological properties. The emergence of distinct peaks of γ-AlOOH in XRD and FTIR spectra indicated the strong interaction between γ-AlOOH and the blend. Morphological analysis revealed significant changes in the surface characteristics of the pristine blend upon incorporation of γ-AlOOH. Thermogravimetric analysis (TGA) confirmed the improved thermal stability of the nanocomposites, while differential scanning calorimetry (DSC) revealed changes in the glass transition temperature proportional to the γ-AlOOH content. The nanocomposite films demonstrated enhanced mechanical properties, exhibiting a 39.6 % increase in tensile strength at a 5 wt% γ-AlOOH loading. The temperature-dependent dielectric constant, loss tangent, AC conductivity and impedance were analyzed at varying loadings of γ-AlOOH. The 7 wt% γ-AlOOH nanocomposites showed the highest conductivity (1.23×10^{-4} S/cm at 1 MHz) and dielectric constant (244 at 100 Hz) at ambient tem-

K. Meera and **M.T. Ramesan,** "Modulating the Properties of Carboxymethyl Chitosan/Polyethylene Oxide Nanocomposites with Aluminium Oxy Hydroxide: A Comprehensive Study" **International Journal of Biological Macromolecules,** 282, 137034, 2024. https://doi.org/10.1016/j.ijbiomac.2024.137034

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Eco-friendly synthesis, characterization, and properties of copper oxide nanoparticles in cashew gum/polypyrrole blend for energy storage applications

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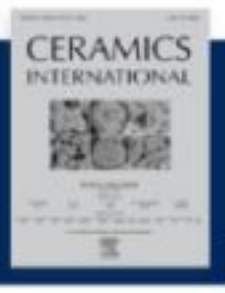
ARTICLE INFO

Keywords:
Cashew gum
Polypyrrole
Copper oxide nanoparticles
Thermal properties
AC conductivity
Dielectric properties
Nyquist plots

ABSTRACT

Conducting biopolymer blend nanocomposites of cashew gum (CG) and polypyrrole (PPy), with varying concentrations of copper oxide (CuO) nanoparticles were synthesized through an in-situ polymerization method using water as a sustainable solvent. The formation of blend nanocomposites was characterized using UV–visible (UV–vis) spectroscopy, Fourier transform infrared spectroscopy (FT-IR), X-ray diffraction (XRD) and field emission scanning electron microscopy (FE-SEM). UV spectroscopy revealed a significant reduction in absorption intensity with the addition of CuO, indicating enhanced optical properties. FT-IR and XRD analysis confirmed the successful incorporation of CuO into the CG/PPy blend. FE-SEM images revealed the uniform distribution of nanoparticles throughout the biopolymer blend, particularly in the 7 wt% sample. TGA and DSC results demonstrated a significant enhancement in thermal stability, increasing from 352 °C to 412 °C and a rise in the glass transition temperature from 89 °C to 106 °C in the blend nanocomposites. The dielectric constant, dielectric loss, impedance, Nyquist plot, electrical conductivity, and electric modulus were extensively examined at

Ayisha Jemshiya Kalladi, K. Arun and **M.T. Ramesan,** "Eco-friendly Synthesis, Characterization, and Properties of Copper Oxide Nanoparticles in Cashew Gum/Polypyrrole Blend for Energy Storage Applications" **International Journal of Biological Macromolecules**, 277, 134473,2024. https://doi.org/10.1016/j.ijbiomac.2024.134473



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Green blend nanocomposites developed from waste sericin, polyvinyl alcohol and boehmite for flexible electronic devices

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ARTICLE INFO

Keywords:
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Boehmite
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Thermal properties
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Conductivity
Dielectric constant

ABSTRACT

The present research article demonstrates the dispersion of boehmite (BHM) nanoparticles into sericin (SER) from silk industry waste with polyvinyl alcohol (PVA) to enhance the optical, mechanical, thermal and electrical characteristics of PVA/SER blend nanocomposites prepared by a simple green synthesis. Techniques such as Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), UV visible spectroscopy, field emission scanning electron microscopy (FE-SEM), high-resolution transmission electron microscopy (HR-TEM), differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA) were carried out for the characterization of the prepared composites. XRD revealed the increased crystallinity of the polymer blend by the reinforcement of BHM. The existence of intermolecular interactions in the blend composite was confirmed by FTIR and UV spectroscopy. The optical bandgap energy of the biopolymer blend decreases with the inclusion of BHM. The SEM and HR-TEM confirmed the homogeneous dispersion of BHM in the blend at 5 wt% loading. The glass transition temperature and thermal stability of the blend nanocomposites were significantly improved by the inclusion of BHM was deduced from DSC and TGA. The dielectric constant and AC conductivity were remarkably increased with the reinforcement of nanoparticles. The activation energy obtained from AC conductivity decreased with temperature. The mechanical properties of the blend nanocomposites (hardness, tensile strength and Young's modulus) were greatly increased in presence of BHM. The 5 wt% sample has the highest tensile strength, Young's modulus, dielectric constant, AC conductivity and optical properties, allowing it to be used to make optoelectronic devices with better charge-storing capacity and flexible-type electrochemical gadgets.

M. T. Ramesan, Soorya Jayan, Ayisha Jemshiya Kalladi, K. Meera and P. Sunojkumar, "Green blend nanocomposites developed from waste sericin, polyvinyl alcohol and boehmite for flexible electronic devices" **Ceramic International**, 50, 36570, 2024. https://doi.org/10.1016/j.ceramint.2024.07.043

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ORIGINAL PAPER

Tuning the Structural, Mechanical, Thermal and Electrical Properties of in-Situ Polymerized Polyindole/Carboxymethyl Chitosan/Nickel Oxide Blend Nanocomposites for Energy Storage Applications

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Abstract
The main objective of the present study was to develop flexible conductive biopolymer blend nanocomposites using polyindole (PIN) and carboxymethyl chitosan (CMC) with various nickel oxide (NiO) nanoparticles by in-situ polymerization techniques. Different techniques were used to study the effect of NiO content on the structural, optical, morphological, thermal, mechanical and electrical characteristics of PIN/CMC blend nanocomposites. Fourier-transform infrared spectroscopy (FT-IR) demonstrated that the introduction of NiO nanoparticles resulted in chemical bonding with the PIN/CMC blend, as evidenced by the formation of a new peak at a wavenumber of 603 cm^{-1}. The lowest optical bandgap energy was found in 10 wt% composites. The increased crystallinity of the blend nanocomposites was evident from X-ray diffraction (XRD) patterns. The scanning electron microscopy (SEM) and the energy dispersive X-ray (EDX) analysis confirmed the presence of NiO nanoparticles in the PIN/CMC blend. High-resolution transmission electron microscopy (HR-TEM) images revealed that the NiO particles were homogeneously dispersed in the blend matrix at a manometer scale. The thermogravimetric analysis (TGA) demonstrated that the reinforcement of NiO significantly improved the thermal stability of PIN/CMC blend from 202 to 223 °C. Electrical conductivity improved significantly as the temperature and nanoparticle

O. Mohamed Hunais, T. A. Ramseena, K. Meera, B. K. Bahuleyan and **M.T. Ramesan,** "Tuning the structural, mechanical, thermal and electrical properties of in-situ polymerized polyindole/carboxymethyl chitosan/ nickel oxide blend nanocomposites for energy storage applications" **Journal of Polymers and the Environment**, 32, 4035 2024. https://doi.org/10.1007/s10924-024-03250-4

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Optimizing the structural, thermal, gas sensing and electrical properties of in-situ polymerized poly(thiophene-co-indole)/silicon carbide nanocomposites for energy storage applications

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Keywords:
Poly (thiophene -co-indole)
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ABSTRACT

Conducting copolymer nanocomposites of thiophene and indole incorporated with silicon carbide nanoparticles [poly (thiophene-co-indole-SiC) (PPSiC)] has been developed by in-situ copolymerization and these nanocomposites were characterized by different analytical techniques. The FTIR peak at 865 cm^{-1} signifies the successful incorporation of SiC nanoparticles in the copolymer matrix. The intensity of the UV-Vis absorbance of the copolymer nanocomposites increased with the nanoparticle concentrations, and PPSiC7 showed the highest intensity. This was in correlation with its low optical bandgap energy (3.032 eV) and high refractive index (2.368) value. XRD revealed the consistent positioning of sharp and distinct crystalline peaks of SiC in the copolymer. SEM revealed the effective dispersion of nanoparticles throughout the matrix and uniform dispersion was obtained for PPSiC7 nanocomposite. HR-TEM images validated the presence of spherical-shaped particles in the nanocomposite with the nano-size distribution of SiC. The surface roughness of the copolymer nanocomposite was evident from AFM analysis. TGA and DSC revealed that PPSiC nanocomposites have better thermal properties than the copolymer. AC conductivity increased with frequency and temperature. The PPSiC7 exhibits a maximum conductivity of 1.5×10^{-2} S/cm at 10^6 Hz and an activation energy of 0.064 eV. PPSiC nanocomposites demonstrated excellent results in degrading dye and detecting ammonia gas at ambient temperature. All analyses showed that the PPSiC7 nanocomposite exhibited superior properties than the copolymer. These admirable properties can be exploited in developing optoelectronic devices, energy storage devices and gas sensors.

R. Gopika, K. Arun and **M.T. Ramesan,** "Optimizing the structural, thermal, gas sensing and electrical properties of in-situ polymerized poly(thiophene-co-indole)/silicon carbide nanocomposites for energy storage applications" **Journal of Alloys and Compounds**, 988, 174226, 2024.
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Development of High-Performance Polyindole/Silicon Carbide Nanocomposites for Optoelectrical and Sensing Applications

R. Gopika, K. Arun, and M. T. Ramesan*

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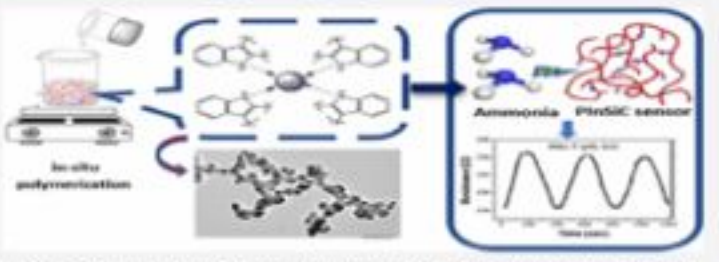
ABSTRACT: In this study, silicon carbide (SiC)-reinforced polyindole (PIn) nanocomposites were prepared by a simple in situ polymerization method. The successful reinforcement of the nanofiller within the host matrix was characterized using different analytical techniques. The chemical bonding of SiC in the polymer was identified by the characteristic peak around 800 cm^{-1} using Fourier transform infrared spectroscopy (FT-IR). The increment in intensity of the absorption and enhanced crystallinity of the samples upon the addition of nanofillers were analyzed using UV−vis spectroscopy and X-ray diffraction (XRD). The prepared specimens showed reduced optical bandgap energy (3.188 eV) and Urbach energy (2.315 meV) with an improved refractive index (2.348). The effect of nanoparticles on the surface morphology of the nanocomposites was studied using scanning electron microscopy (SEM), and a uniform dispersion of fillers in the matrix was found for PInSiC7. A high-resolution transmission electron microscopy (HR-TEM) revealed the shape and average particle size of the sample. X-ray electron spectroscopy (XPS) measurements confirmed the formation of the nanocomposite by exhibiting the presence of all elements in the corresponding spectra. The thermal stability and glass transition temperature of the nanocomposites were significantly improved with the addition of SiC. The temperature-dependent AC conductivity, dielectric parameters, complex impedance, and electrical modulus were also evaluated using an impedance analyzer. The increased electrical characteristics of the PInSiC7 sample can be attributed to the uniform spread and strong synergetic interaction of SiC with PIn. The results thus showcased the potential of the samples for use in optical and energy storage applications. This study was also extended to understand the ammonia sensing properties, which make it possible to design and develop gas sensors using the PInSiC nanocomposites.



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In-situ polymerization of polythiophene/silicon carbide nanocomposites for gas sensing and optoelectronic devices

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Keywords:
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Thermal properties
Dielectric constant
Conductivity

ABSTRACT

Silicon carbide (SiC)-reinforced polythiophene (PTh) nanocomposites were synthesized by oxidative in-situ polymerisation. The successful inclusion of SiC nanoparticles into the PTh was confirmed by the characteristic peak of Si–C bond around 865 cm^{-1} in the Fourier transform infrared (FT-IR) spectra. The X-ray diffraction (XRD) patterns demonstrate that the amorphous nature of PTh reduces with the addition of SiC. The intensity of UV–Vis absorbance increased proportionally with filler loading, indicating improved optical properties for PThSiC7 (polythiophene/silicon carbide 7 wt%) nanocomposite compared to pristine PTh. Field emission scanning electron microscopy (FE-SEM) images illustrate the changes in surface morphology of PTh with the addition of SiC and uniform dispersion was observed in PThSiC7. The formation of spherical-shaped moieties was confirmed using transmission electron microscopy (TEM). The shifts in degradation and glass transition temperatures towards higher values were attributed to the enhanced thermal properties of the nanocomposites. Temperature-dependent studies on the electrical and dielectric properties of the samples underscored the excellent conductivity exhibited by PThSiC7 (7×10^{-3} S/cm) with a low activation energy of 0.058 eV. In response to the growing demand for gas sensors, samples were tested to sense ammonia gas, demonstrating that

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