



Thermo-Electrical Performance of Ferrite-Doped Chitosan Nanocomposites Modified with Graphene Oxide

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The growing demand for renewable, multifunctional materials has spurred interest in nanocomposites for energy, biomedical and environmental uses. In this study, magnetic chitosan (MCS) and magnetic chitosan–graphene oxide (MCS/GO) nanocomposites were synthesized *via* a simple coprecipitation method. The structural, thermal and electrochemical properties were analyzed using XRD, FESEM-EDAX, TGA and impedance spectroscopy. XRD confirmed nanocrystalline phases (7.6 nm) with uniform magnetite dispersion in the polymer–GO matrix. TGA showed a residual mass of ~88% at 800 °C for MCS/GO, indicating high thermal stability. Impedance analysis showed easier charge movement through the bulk at higher frequencies; both resistance and reactance decreased with temperature, confirming thermally activated transport. The activation energy (~168 meV) indicates efficient GO-assisted carrier hopping, making MCS/GO nanocomposites promising for energy-efficient sensors, solid-state batteries and thermally stable electronic devices.

Keywords: Magnetic chitosan, Graphene oxide, Nanocomposite, Thermal stability, Impedance spectroscopy.

INTRODUCTION

The growing demand for sustainable and multifunctional materials has catalyzed significant interest in bio-based nanocomposites. Among them, chitosan, a natural polysaccharide derived from the deacetylation of chitin, stands out due to its biodegradability, biocompatibility and rich chemical functionality. All these attributes make chitosan apt for many applications like biomedicine, electronic devices and water purification [1,2].

To improve the performance and applications of chitosan, magnetic nanoparticles especially magnetite (Fe₃O₄), are often incorporated into its structure, creating magnetic chitosan (MCS). Such a material exhibits superparamagnetic behaviour as well as superior mechanical strength in contrast to pure chitosan. The incorporation of magnetic nanoparticles also introduces additional active sites and increases the overall surface area, which enables better interaction with surrounding molecules. This also improves the nanocomposites' chelation capacity and reactivity thereby establishing direct connection between enhanced properties and processing techniques [3,4]. These

features make MCS a viable and attractive material to be used in diverse fields like biosensing, drug administration and environmental remediation [5]. Nevertheless, challenges such as limited electrical conductivity and structural instability under specific environmental conditions hinder its application in advanced biomedical and electronic technologies.

Graphene oxide (GO), a chemically modified derivative of graphene, has emerged as a promising additive for polymer matrices due to its exceptional mechanical strength, thermal stability, electrical conductivity and abundance of oxygenated functional groups like hydroxyl, carboxyl and epoxide [6,7]. Incorporating GO into chitosan matrices improves their biocompatibility, adsorption efficiency and structural integrity [1].

When graphene oxide (GO) is combined with magnetic chitosan, the resulting nanocomposite shows noticeable improvement in its thermal as well as mechanical properties. The presence of GO also improves electrical conductivity, making the material even more versatile for advanced technological applications. These magnetic chitosan–graphene oxide (MCS/GO) composites are thus positioned as promising candidates