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RESEARCH ARTICLE

Tailoring Ethyl-Cellulose Films With NiO and BaO Nanoparticles for Thermally Stable Optoelectronic and Dielectric Applications

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ABSTRACT

This study is an attempt to reinforce the ethyl cellulose with NiO and BaO nanoparticles (NPs) for a high-performance and multifunctional nanocomposite. In this context, *fcc* NiO and tetragonal BaO NPs were chemically prepared and dispersed in EC by solution casting. XRD results showed that NiO-BaO/EC nanocomposites are semicrystalline, and their crystallinity index decreased upon NPs filler incorporation. SEM analysis showed the semispherical morphology of the NPs and the uniform distribution on the films' surface. FTIR analysis revealed the strong physical interaction between NiO NPs and the EC's reactive groups. Additionally, UV–Vis spectra revealed that NiO NPs impact the optical parameters of EC more pronouncedly than BaO and NiO/BaO mixed oxides. The direct (indirect) band gap of EC decreased from 4.7 (3.5) to 3.7 (2.0) eV. In addition, the refractive index increased from 2.045 to 2.23 at 2 wt% NiO. This suggests the suitability of NiO/BaO/EC films for optoelectronic applications. The thermal analyses (TGA-DTA and DSC) were carried out to study the impact of the NiO/BaO NPs on the EC's thermal stability and transition temperatures. The dielectric parameters were investigated at room temperature (RT). The maximum conductivity of EC increased from 2.69×10^{-6} to 5.17×10^{-6} S/cm and 4.58×10^{-6} S/cm upon loading 2 wt% of NiO and 2 wt% of BaO NPs, respectively. The BaO NPs improved the dielectric constant and minimized the loss. This study reveals the possible development of BaO/EC composites for supercapacitors and energy storage applications.

1 | Introduction

Development of high-performance polymeric nanocomposites (inorganic or organic nanoparticles (NPs) dispersed in a polymer matrix) is gaining increasing attention worldwide. The improved physicochemical features, feasible handling and fabrication, cost-effectiveness, mechanical flexibility, and property tunability encourage the use of these nanocomposites in various material engineering, industrial and electro-technological, and biomedical applications [1–3].

Cellulose is a highly available natural/organic polysaccharide polymer on the Earth's surface. When some of the OH groups are replaced with ethyl ether/acetyl groups, the resultant (alkyl) derivative is ethyl cellulose (EC). EC is a linear hydrophobic polymer that is soluble in several organic solvents such as ethanol and toluene, with film-forming ability [4–6]. EC also exhibits thermoplastic features, facile degradation, safety for consumption, resistance to moisture, oxygen, heat, and light, low thermal conductance (0.2 W/m/K), and physiological inertness [7–10]. Moreover, EC has a semi-crystalline