Electrical Conduction Mechanisms in Hybrid composite-Based Vinyl Resin Reinforced with Green Microcrystalline Cellulose and/or Carbon Nanotubes

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Abstract

This work investigates the electrical and dielectric properties of a novel composite based on vinyl resin emulsion reinforced with green microcrystalline cellulose (MCC) and carbon nanotubes (CNT) particles. The electrical and dielectric responses of each sample were evaluated by measuring AC electrical conductivity over a temperature range of 260–340 K and a frequency range of 100 Hz–1 MHz. The electrical conductivity dispersion follows Jonscher's power law, indicating that the mechanism is governing by the correlated barrier-hopping (CBH) model. Dielectric properties were aanalyzed using the electric modulus formalism and interpreted according to the Havriliak-Negami model. For the neat vinyl resin emulsion (VR), the observed relaxation process corresponds to α-relaxation. Upon addition of the fillers, dipolar polarization of water molecules is observed below the glass transition temperature, while a combination of α-relaxation and interfacial polarization, known as Maxwell–Wagner–Sillars (MWS) polarization, is evident above the glass transition temperature. The activation energies associated with these processes were determined using the Arrhenius law. Dielectric analysis further enabled assessment of the reinforcement–matrix interfacial adhesion, which plays a critical role in controlling the electrical conductivity performance of the composite materials.

Keywords: Vinyl resin, microcrystalline cellulose (MCC), carbon nanotube (CNT) particles, Havriliak–Negami model, Jonscher's power law, electrical conduction mechanisms.

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References:

[1] Z. El Ansary, L. Krei, F. Ztak, A. Triki, L.C. Costa, M. El Hasnaoui. Electrical and dielectric properties of biocomposites-based vinyl resin emulsion reinforced with green microcrystalline cellulose. *Braz. J. Phys.* 55 (2024) 47.

[2] S. Larguech, L. Kreit, A. Zyane, A. Triki, M. El Hansaoui, M.E. Achour, A. Belfkira. Dielectric properties of microcrystalline cellulose/multi-wall carbon nanotubes multi-scale reinforced EVA/VeoVa terpolymer. *J. Compos. Mater.* 56 (2022) 3861–3880.