Optical and Quantum Electronics 56 (2024) 1224
https://doi.org/10.1007/s11082-024-07113-z

Reinforcing the structure, optical, and dielectric spectroscopies of poly(ethylene oxide)/poly(methyl methacrylate) thermoplastics by CoFe nanoparticles for optoelectronic device fabrication

Tarek I. Alanazi[1], Adel M. El Sayed[2*]

[1]Department of Physics, College of Science, Northern Border University, Arar 73222, Saudi Arabia

[2]Physics Department, Faculty of Science, Fayoum University, El-Fayoum 63514, Egypt

Abstract

Hybrid polymer nanocomposites (HPNC) with improved optical and magneto-dielectric properties are an exciting class of materials from economic and industrial points of view. In the present work, CoFe magnetic nanoparticles (NPs), and HPNC based on a polyethylene oxide (PEO)/polymethyl methacrylate (PMMA) matrix were synthesized by simple and cost-effective chemical methods. The NPs morphology, HPNC structure, and film surface were investigated using FE-scan electron microscopy, XRD (X-ray diffraction), and Fourier transform-infrared (FT-IR) techniques. The PEO/PMMA blend exhibits 39% crystallinity, which is reduced upon 1.0 wt% CoFe NPs addition. The uniformly distributed CoFe NPs resulted in a reduction in the FTIR absorption band's intensity. The optical spectra displayed the high transmittance of the blend matrix and CoFe/PEO/PMMA. The influence of CoFe content on the Urbach energy, refractive index, and carrier concentration is reported. The optical band gap (E_g) was evaluated by two different methods and was found to decrease from 5.0 to 4.5 eV. The dielectric spectroscopy was studied in at frequencies of 1×10^2–5×10^6 Hz, and temperatures in the range of 30–110 $^{\circ}$C. The real (imaginary) dielectric constant, modulus, and the correlation between the dielectric constant and dc conductivity were studied. The blend's ac conductivity was 4.14 x 10^{-4} S/m, which increased to 6.91 x 10^{-4} S/m upon 1.0 wt% CoFe NPs doping. The enhancement in the structural, optical parameters and dielectric features, and the ac and dc conductivities, make CoFe/PEO/PMMA HPNC the best candidate for advanced optoelectronics, photonic devices, and microcapacitors.

***Keywords*:** PEO/PMMA blend; CoFe NPs; Refractive index; Magneto-dielectric devices.