

Abstract

The rapid advancement of electronic and communication systems has led to increasing electromagnetic (EM) pollution, which not only disrupts the performance of electronic equipment but also poses potential risks to living organisms. This necessitates the development of lightweight, flexible, and efficient electromagnetic interference (EMI) shielding materials. This thesis presents the fabrication and characterization of nanoparticle-reinforced polyolefin elastomeric foams that are lightweight, flexible, and easily processable, designed for EMI shielding and thermal management applications. Ethylene–octene copolymer (EOC) was chosen as the base polymer for its unique combination of thermoplastic toughness and elastomeric flexibility nature. A combination of melt and solution mixing method with chemical foaming was employed to prepare porous EOC-based nanocomposites incorporating various conductive and magnetic fillers. Carbon black (CB), multi-walled carbon nanotubes (MWCNTs), reduced graphene oxide (RGO), and cobalt ferrite (CoFe_2O_4) were systematically introduced to tune microstructure, density, electrical and thermal conductivity, mechanical strength, and EMI shielding characteristics. CB-based foams achieved percolation at higher loadings with a shielding effectiveness (SE) of -26 dB. One-dimensional MWCNTs formed segregated conductive networks at low percolation thresholds, delivering high conductivity and absorption-dominated EMI shielding (SE -25.5 dB). Hybrid RGO–MWCNT systems established three-dimensional conductive architectures, enhancing EMI shielding (26.5 dB) and thermal conductivity ($\sim 65\%$ improvement) at low filler contents. The integration of magnetic CoFe_2O_4 with MWCNTs exploited synergistic dielectric and magnetic losses, achieving an EMI SE of ~ 29 dB, alongside improved thermal conductivity. Across all systems, the microcellular foam architecture played a pivotal role in reducing density, promoting multiple internal reflections, and improving impedance matching. Comprehensive characterization, including morphological (SEM/TEM), structural (XRD, Raman, XPS), electrical, thermal, mechanical, and electromagnetic analyses, validated the structure–property relationships. The results establish POE-based nanocomposite foams as a versatile platform for next-generation EMI shielding materials that combine low weight, flexibility, mechanical robustness, and thermal dissipation. Potential applications span flexible electronics, aerospace, automotive, defence, and smart wearable devices. This work demonstrates an industrially viable route to integrate conductive and magnetic nanofillers into polymer foams for multifunctional performance with absorption-dominated EMI attenuation.

Keywords: *Nanocomposite foam, conductive filler, EMI shielding, absorption dominated, morphological, dielectric loss, magnetic loss*