

Dielectric Nanoparticles for EMI Shielding Applications

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Abstract: The rapid growth of electronic devices, wireless communication systems, and high-frequency technologies has significantly increased electromagnetic radiation in modern environments, leading to serious electromagnetic interference (EMI) challenges. EMI can disrupt electronic systems, decrease device reliability, and weaken communication networks. As a result, developing efficient, lightweight, and sustainable EMI shielding materials has become a key research focus. While conventional metallic shields provide high electrical conductivity and strong reflection-based shielding, they also have disadvantages, including high density, corrosion susceptibility, and limited design flexibility. Recently, dielectric nanoparticles have become promising components in advanced EMI shielding materials because of their ability to attenuate electromagnetic waves through polarization and dielectric loss mechanisms. Nanomaterials such as SiO₂, TiO₂, BaTiO₃, Gd, and ZnO exhibit strong interfacial polarization in response to electromagnetic fields, thereby enabling effective energy dissipation. When integrated into polymer matrices, these nanoparticles enable the fabrication of lightweight nanocomposites with tunable dielectric properties and improved impedance matching. This keynote will discuss recent advancements in designing and engineering dielectric nanoparticle-based composites for EMI shielding applications, with a particular focus on sustainable and bio-based materials. A case study will highlight the development of structural insulated panels made from date palm felt reinforced with functionalized graphene oxide, where agricultural waste fibers are combined with epoxy matrices and graphene nanosheets to produce multifunctional composites. These hybrid materials show improved mechanical strength, enhanced hydrophobicity, and promising electromagnetic shielding capabilities, demonstrating the potential of combining natural fibers with nanomaterials for construction and electronic protection. Finally, future directions for versatile, environmentally friendly EMI shielding materials will be explored, emphasizing nanotechnology's role in tackling the increasing challenges of electromagnetic pollution in modern technological environments.

Keywords: Electromagnetic interference shielding; Graphene nanoparticles; Dielectric nanoparticles.

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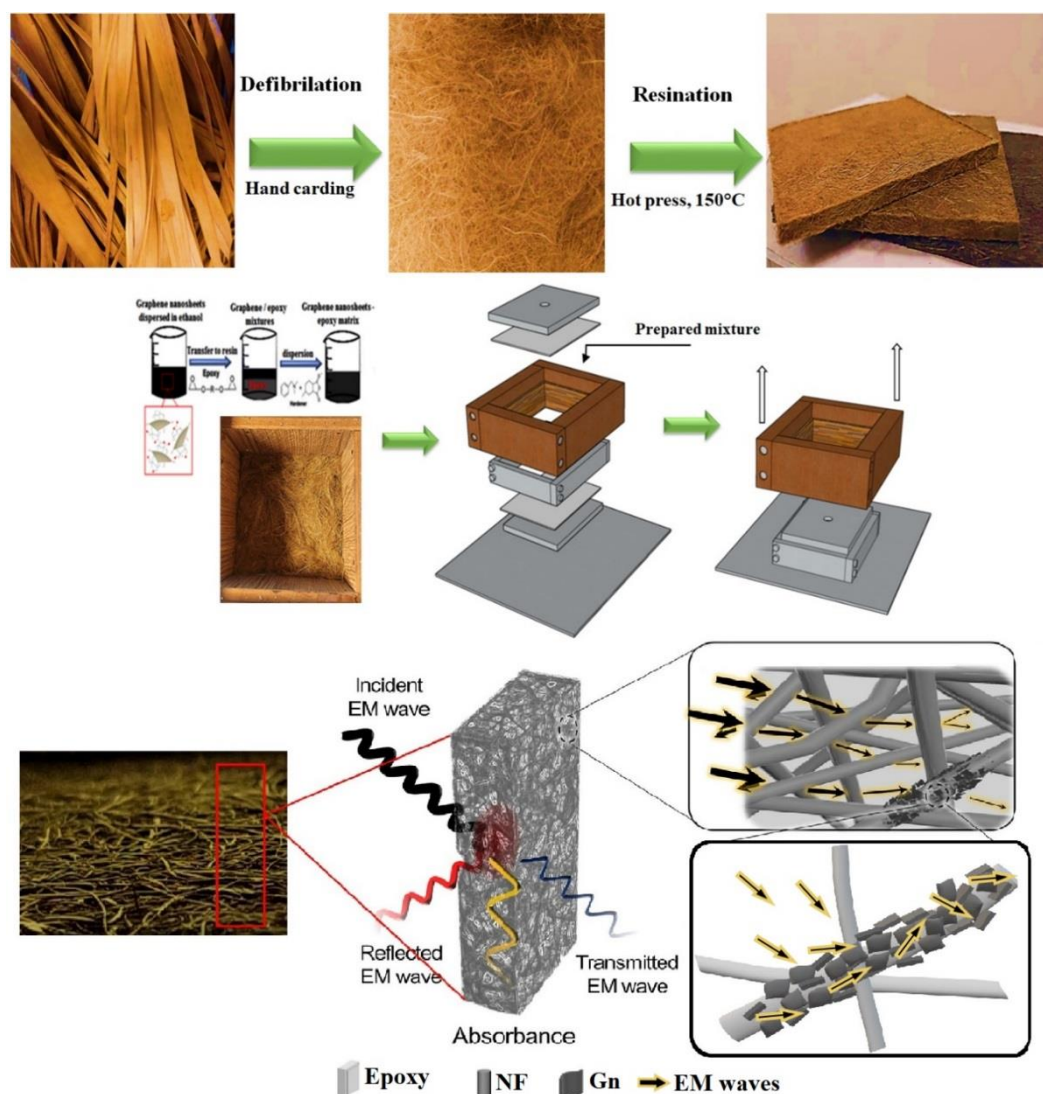


Figure 1: Graphene-based nanocomposite panels manufacturing process for EMI shielding application.