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# Understanding the Synergistic effect in Multifunctional and Lightweight Hybrid Graphene Nanoplatelet and Glass Fiber-Reinforced Composites

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## ABSTRACT

This work explores hierarchically structured hybrid polypropylene (PP)-based composites reinforced with graphene nanoplatelets (GnP) and glass fiber (GF), fabricated by injection molding, to elucidate the synergistic effect and how it can be tailored to produce properties and functionalities not possible in biphasic composites. In this hierarchical system, the GnPs (i.e., nano-sized filler) are chemically and electrostatically attached to the GFs (i.e., micro-sized filler), favoring load transfer at the interface, while simultaneously enhancing the crystalline microstructure of the PP matrix, by promoting trans-crystallization and β-crystal formation. Furthermore, the volume exclusion effect induced by the GFs, promotes the formation of GnP-based thermally conductive networks, thereby facilitating phonon transfer. These mechanisms were found to be maximized with a concentration of 0.5 wt.%. GnP, thereby producing the greatest synergistic effect (i.e., the interaction between two reinforcements that produces an effect greater than their simple addition). Overall, understanding these mechanisms has led to the development of hybrid composites exhibiting a synergistic effect of up to ~52%, ~39%, and ~68% for the specific tensile strength, flexural strength, and thermal conductivity, respectively. Ultimately, this work demonstrates the feasibility of fabricating hierarchically structured hybrid composites with synergy-induced properties that can be tailored for a variety of novel high-performance applications, where mechanical performance, thermal conductivity, and lightweighting are imperative to meet the energy efficiency requirements of the future.