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Synthesis of Graphene Nanocomposites with Enhanced Thermal Conductivity and Mechanical Strength for Use in Heat Exchanger and Fuel Storage Technology

Stainless steel's high strength and thermal conductivity make it essential in heat exchangers and fuel storage technology. However, steel is corrosive, expensive, and its production is harmful to the environment. Polymer blends with enhanced properties can potentially serve as an alternative to stainless steel, as they have wide applicability due to their flexibility and durability. Graphene is an extremely lightweight, strong, and conductive material. Previous studies that have investigated the use of graphene nanoparticles (GNPs) in plastics to create an alternative to stainless steel in heat exchangers failed to achieve a necessary thermal conductivity coefficient above 2 W/m·K. Polymer blends with GNPs could have the advantage over stainless steel as they would be cheaper, lightweight, recyclable, and non-corrosive. Researchers in this study hypothesized that adding GNPs to immiscible copolymer blends, rather than homopolymer blends, would decrease the percolation threshold of graphene and achieve sufficient thermal conductivity at a lower wt% of GNPs. The GNPs should localize inside one phase while being repelled by the other immiscible polymer. Reducing the amount of graphene used would be optimal for cost-efficiency. Three copolymer compositions of polystyrene/poly(methyl methacrylate) (PS-PMMA), polypropylene/poly(methyl methacrylate) (PP-PMMA), and poly(butylene adipate-co-terephthalate)/poly(lactic acid) (PBAT-PLA) were compared to three homopolymer compositions of PS, PP, and PBAT with increasing concentrations of GNPs. Blends were tested for tensile properties, izod impact strength, and thermal conductivity. The PP-PMMA and PBAT-PLA blends at 25 and 20 wt%, respectively, achieved desirable thermal conductivity coefficients near 2.3 W/m·K while maintaining sufficient strength. The PBAT-PLA blend holds the most potential. Its biodegradability allows for it to be environmentally friendly. It also formed a favorable bicontinuous phase (substantiated by TEM imaging) and proved to have the highest flexibility.

Selected References

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