Enhancing Mechanical Properties of Graphene-Reinforced Photopolymer Resins via Additive Manufacturing

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This work explores the mechanical behavior of graphene-enhanced polymer nanocomposites produced through vat photopolymerization (VPP) based additive manufacturing. To achieve effective reinforcement, graphene nanoplatelets (GNPs) were surface-treated with a coupling agent and incorporated into a nylon-like photocurable resin at varying concentrations (0.025–0.2 wt.%). Among the tested formulations, a loading of 0.05 wt.% GNPs delivered the best mechanical performance, with notable increases of 45.1% in ultimate tensile strength and 43.5% in Young's modulus. The effects of key printing parameters specifically, layer thicknesses of 35, 50, and 65 µm, and UV exposure durations of 50, 60, and 70 seconds, were systematically examined. Results indicated that finer layers and extended exposure times contributed to improved mechanical integrity. Additionally, post-curing the printed parts at 120 °C for 2 hours further enhanced the tensile strength, reaching up to 67.16 MPa. Microscopic analyses, including SEM and optical imaging, revealed uniform dispersion of GNPs at low loadings, while Raman spectroscopy confirmed successful incorporation of graphene with minimal structural defects after curing. The optimized nanocomposite formulation was utilized to manufacture lightweight eyeglass frames featuring hexagonal and triangular lattice geometries, illustrating the material's applicability in real-world structural components. In conclusion, this study highlights the promise of VPP-based additive manufacturing for creating high-performance, graphene-reinforced composites suited for use in aerospace, automotive, and wearable technologies.

References

[1] Shammah Aldhanhani, Murad Ali, Rami Adham Elkaffas, Haider Butt, Yarjan Abdul Samad, *ES Materials & Manufacturing*, 26 (2024) 1303.

Figures

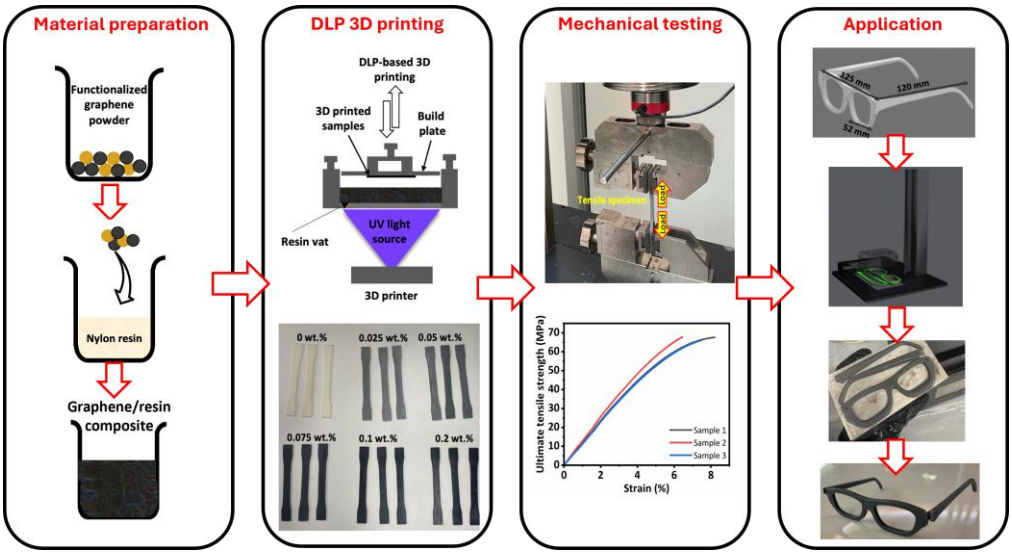

Figure 1: Stress-strain response and eyeglass frame designs made from optimized graphene nanocomposites