Printable Biodegradable Conductive Nanocomposites for Sustainable Electronic Applications

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More than 50 million tons of electronic equipment waste is generated per year, creating a strong demand for sustainable conductive materials. Yet, biodegradable conductive materials face a critical tradeoff: achieving adequate electrical conductivity requires high loadings of conductive fillers that cause severe embrittlement, preventing intensive processing methods such as 3D-printing. This study investigated whether polymer blend toughening could enable a biodegradable material combining electrical conductivity with sufficient ductility for 3D printing and extrusion-based manufacturing. Contact angle measurements and Young-Dupré analysis predicted thermodynamically favorable graphene nanoplatelet (GNP) localization within polymer phases. Biodegradable polybutylene adipate terephthalate (PBAT), the toughening agent, and polylactic acid (PLA) were melt-compounded in 3:1 ratio with 5-20 wt% GNP. Results demonstrated successful combination of electrical and mechanical performance. The material achieved conductivity of 0.2-1 S/m while maintaining a ductility of 2.5% at 20 wt% graphene. 3D-printed samples showed superior Young's Modulus, tensile strength, and toughness compared to printed samples, revealing printed samples were optimized for mechanical robustness. Overall, this represents first material combining adequate conductivity, 3D printability, and complete biodegradability. Applications include biodegradable agricultural sensors, temporary medical electrodes, and custom-printed circuits biodegrading after use, enabling sustainable electronics previously impossible to manufacture.

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