High-yield Water-Based Production of Pristine Graphene Nanosheets for Industrial Applications

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Abstract

Achieving sustainable and high-yield liquid-phase exfoliation of graphene in water remains a significant challenge. Conventional strategies to improve yield often rely on chemical functionalization or exfoliation in toxic organic solvents, compromising either material quality or environmental compatibility. In this work, we introduce a simple pre-treatment of graphite flakes to enable high-yield exfoliation of few-layer graphene directly in water. Within one hour of sonication, a graphene yield exceeding 50% was achieved, corresponding to a production rate greater than 0.2 g h^{-1}. This approach eliminates the need for harsh chemicals while preserving structural integrity and enabling scalable, environmentally benign production. Raman spectroscopy and electron microscopy confirm the production of large-area graphene nanosheets with lateral dimensions of 1-3 µm, high transparency, few-layer thickness (<10 layers), and low defect density (I_D/I_G ~0.1; $I_D/I_{D'}$ ~4), indicating minimal edge defects. To demonstrate processability, the aqueous graphene dispersion was formulated into inks and pastes, and rheological properties were systematically analyzed. As proof-of-concept device demonstrations, the graphene nanosheets were integrated as the active channel in a field-effect transistor and as conductive elements in e-textile-based Joule heaters, and polymer nanocomposites applications. This scalable and environmentally benign strategy provides a viable pathway toward the production of electronic-grade graphene in water for sustainable commercial applications.

Figure

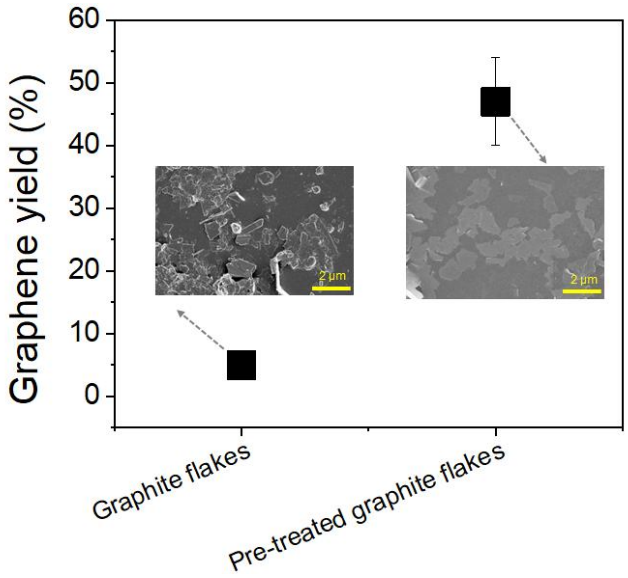

Figure 1: Graphene yield versus initial and pre-processed graphite precursors (Inset: SEM images of graphite and pre-processed graphite exfoliated graphene nanosheets)