# Scalable production of low-defect graphene nanosheets by efficient water-assisted mechanochemical exfoliation

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Graphene is a two-dimensional carbon nanomaterials with superior electronic, thermal, and mechanical properties and currently explored in advanced electronics, transparent protective coating, energy storage devices and polymer composites. It is highly desirable to economically produce high-quality graphene in industrial quantities to commercially realize its applications; however, no scalable method exists. Mechanochemical approaches to graphene nanosheets synthesis offer the promise of improved yields, new reaction pathways, and greener and more efficient syntheses, making them potential approaches for low cost production of graphene nanosheets.

Here we report the scalable production of single- and few-layer graphene nanosheets with low defect densities by an efficient water-assisted mechanochemical exfoliation of graphite in N-methylpyrrolidinone (NMP). The mechanochemical exfoliation could be further improved by applying high speed homogenization and ultrasonication as pretreatments. It is found that the former step homogenized the graphite-solvent solution while the latter provided sufficient energy to weaken the van der Waals interactions and promoted the intercalation of solvent molecules into the graphene sheets within bulk graphites. Significantly, when NMP with water was employed as the cosolvent in the mechanochemical exfoliation, it was found to be possible to produce graphene nanosheets with less defect.

Detailed materials characterization including transmission electron microscopy, Raman spectroscopy, and UV-Vis absorbance spectroscopy suggest that single- and few-layer graphene nanosheets were successfully prepared with the concentration and yield up to 21.9 mg/mL and 43.8% respectively. The yield may be further improved by optimizing the process conditions. Our work provides a guide of rational design of a solvent system to improve the yield and stability of the exfoliated materials.

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