# Fundamentals and Process Engineering of Graphene Exfoliation: Layer Separation Mechanisms to Next-Generation Functional Applications

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**Abstract** Graphene is a two-dimensional carbon nano-material that has gained remarkable attention due to its exceptional electrical conductivity, mechanical strength, thermal stability, and high specific surface area. The large-scale utilization of graphene depends on effective exfoliation of graphite through suitable physical and chemical approaches. Commonly adopted methods include ultrasonication-assisted liquid phase exfoliation, chemical oxidation using different oxidizing agents for graphene oxide preparation, and shear or cavitation-based techniques for scalable production. The incorporation of conductive additives and surfactants plays an important role in improving dispersion stability and preventing the restacking of graphene layers. The influence of processing strategies on structural quality and conductivity is significant for practical implementation in advanced applications such as anticorrosion coatings, sensors, flexible electronics, energy storage systems, and conductive polymer composites. These materials further enable high-performance supercapacitors, lithium-ion batteries, EMI shielding materials, wearable electronic devices, smart self-healing coatings, and advanced electrochemical sensing platforms.

References

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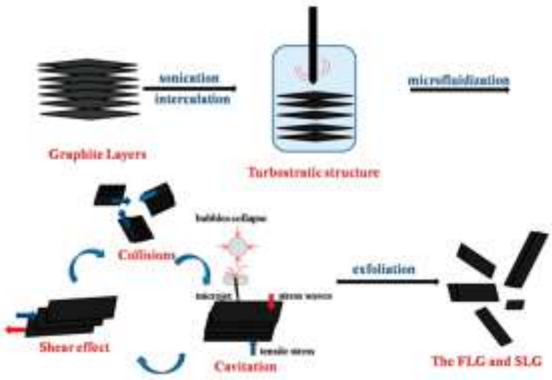
Figures




A B C

**Figure 1:** Mechanism behind the exfoliation of graphene (A) exfoliation of graphene by different techniques (B) the trade-off between material quality, production cost, and application areas, (C) SEM analysis for exfoliated graphene.