

GRAPHENE OXIDE SUSPENSIONS

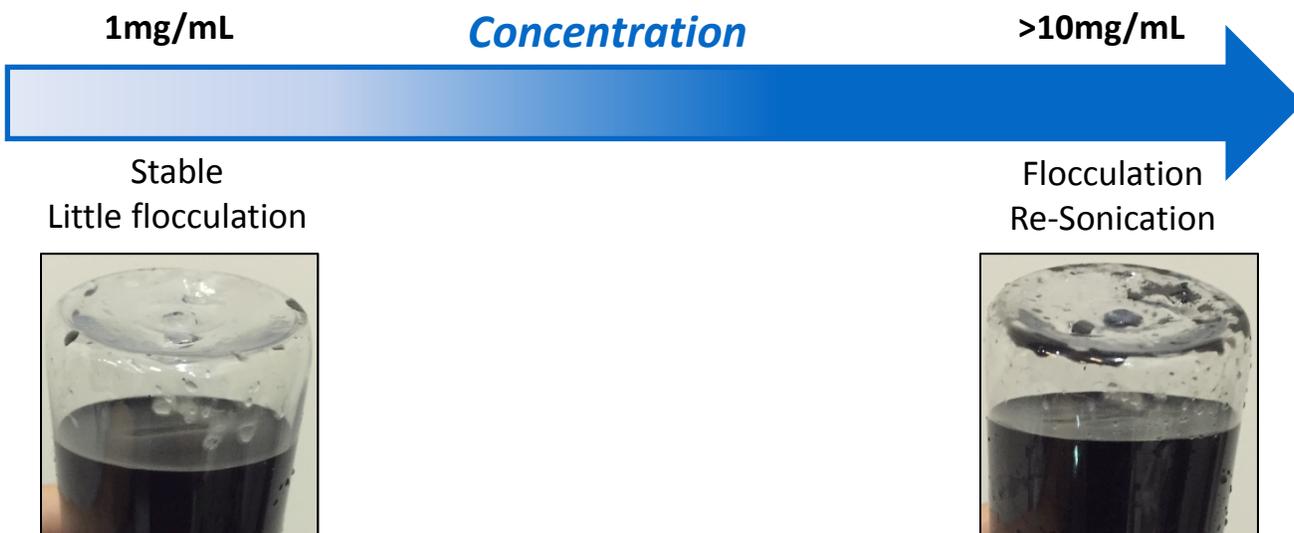
Guidelines for suspending graphene oxide in solvents

Background

Graphene can be used to improve the mechanical, electrical, and thermal properties of the host into which it is incorporated. Enhancing the thermal and electrical properties generally requires higher loadings (on the order of a few weight percent) whereas enhancing the mechanical properties in general requires less than one weight percent. As with other fillers, it is important that graphene is dispersed homogeneously into the host matrix in order to obtain its beneficial properties. Successful mixing techniques include but are not limited to solvent blending, melt & powder blending or in situ polymerization. Most carbon-based materials, including graphene oxide, absorb moisture from the air so for certain applications it is recommended that users remove the water using a low temperature oven (100°C for 1 hour) or desiccant prior to initiating the mixing process.

Low Viscosity Solvents

For dispersion of Garmor's edge-oxidized graphene oxide (EOGO) in low viscosity hosts such as ultrapure water, ethanol, or DMF, add the appropriate amount of dried EOGO to the solvent and sonicate the suspension for 60 minutes in an ultrasonic bath. The power of the ultrasonic bath needs to be sufficient to overcome the self-attracted/flocculation of the particles and we have based our sonication times on a 120W bath sonicator. A concentration of 1 mg EOGO/mL or less will yield the best suspensions and should be used within 60 minutes of sonication. Suspensions with concentrations between 1 - 5mg EOGO/mL are obtainable, but will flocculate more readily and after a few hours will form sediment at the bottom of the container. Higher concentrations of graphene oxide are plagued by particle flocculation which forms larger particles in suspension until they drop out of suspension. Visually inspecting the suspension can help identify if a suspension needs to be re-sonicated. This can be accomplished by inverting the bottle. If any sediment is present, additional sonication is likely needed.



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Sonication

Horn sonicators are considered more powerful relative to a bath sonicator. The more powerful horn sonicator will do a better job of dispersing EOGO in a low viscosity liquids host.

High Viscosity Solvents

For high viscosity hosts such as epoxies or resins, one may need to use a high-speed shearing mixer to incorporate and uniformly disperse the EOGO in the host epoxies or resins. Due to the higher viscosity the dispersion is stable for a longer period of time.

Stability of Suspension

EOGO that has been suspended in a liquid host for a long period of time should be resonicated to re-suspend the EOGO in the liquid host and break apart any aggregates that may have formed in storage. Suspensions that have been stored for over a year have been successfully re-suspended by this process.

8-month old suspension of 1.2mg EOGO/mL

Subjected to sonication times in a 120W bath



t=0



t=20 mins



t=40 mins



t=60 mins

Contaminants

EOGO material will chelate in the presence of metal ions and flocculate quicker in their presence. Successful suspension and storage of EOGO in a solution requires that the host be devoid of metal ions. It is also necessary, to store the suspension in a plastic (*e.g.*, polypropylene, polyethylene or teflon) or quartz containers that is devoid of metal ions. The majority of glass bottles have small amounts of sodium that can be leached from the bottle and induce flocculation at very low concentrations. Some metal ion free glassware can be found in the semiconductor industry.