XG sciences -Dispersion Notes

General

xGnP® Graphene Nanoplatelets are very thin flat particles, (1 -20 nanometers in thickness) with large diameters (1 – 50 microns). Like other nanoparticles, the small size gives rise to certain handling issues. We ship many of our platelets in a granular form, which are friable collections of individual platelets that prevent agglomerations and are easily broken with mechanical agitation. To achieve optimum properties and performance, xGnP® Graphene Nanoplatelets must be thoroughly and completely dispersed.

XG Sciences supplies xGnP® Graphene Nanoplatelets in various sizes and grades, and proper dispersion is a function of time, energy and the host media. In general, smaller particles disperse better than larger particles; dispersion is better into lower viscosity materials, and surface-treatment can improve dispersion and/or adhesion with various resins..

Dispersion into Non-Aqueous Solvents

Some organic solvents are effective in obtaining a good dispersion. Suggested solvents include N-methylpyrrolidone (NMP), dimethylformamide (DMF), tetrahydrofuran (THF), toluene, ethyl acetate, isopropanol, ethanol, acetone, methyl ethyl ketone (MEK) and chloroform, 2 amino-butane and other polar solvents.

Probe sonication is the preferred method of dispersing into non- viscous fluids. High shear mechanical mixing is suitable for viscous media.

Dispersion into Aqueous Systems

xGnP® Graphene Nanoplatelets can be dispersed into water with probe sonication or high shear mixing. Adjusting the pH to 7-9 is useful to maintain dispersion. If desired, dispersion aids can be utilized, such as:

- Sodium dodecylbenzene sulfonate - (SDBS) – (solid)
- Poly(sodium styrene sulfonate) – (PSS) – (~70k Mw, 30% H2O solution)
- Polyoxyethylene octyl phenyl ether – (Triton X-100)

Normally, particles that settle out of suspension can be re-dispersed with the reapplication of high energy mixing. Suspensions that have settled for only a short period can be re-dispersed with mild agitation (shaking the jar).

Dispersion into Thermoplastic Matrix

It may be necessary to experiment to determine the best method for your resin system.

- Some manufacturers have introduced specially designed screws for nanocomposites.
- If available, counter-rotating screws have shown good results in many materials.
- Lower melt viscosity will improve dispersion. This can sometimes be achieved by increasing processing temperatures or by switching to a polymer with a higher melt index.

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- In general, pre-mixing graphene nanoplatelets with powdered polymers, rather than pellets, result in better dispersion.
- Especially with resins in a powder format, it may be advisable to mix xGnP® Graphene Nanoplatelets with powder before feeding into the extruder.

xGnP® materials are available in dispersion form and can be used directly in compatible formulations. XG Sciences works with compounders. Please ask us for a recommendation for your resin system.

Dispersion into Thermoset Resin Matrix (Epoxies, Urethanes, etc.)

In low viscosity resin systems (<100 centipoise), mixing xGnP® directly into the resin with a high shear mixer is effective. Sonication with an ultrasonic probe may work better in lower viscosity systems. In higher viscosity systems, heat and/or the use of high shear in-line dispenser designed for high viscosity systems may be required. Also, good results have been obtained with a high-shear 3 roll mill. A balance must be stuck when using high shear mixing since prolonged use will cause the platelets to deform.

The rate of xGnP® addition to the resin is important. Gradual addition with continuous mixing is suggested.

Notes

- **Suspension Resistivity:** As xGnP® is dispersed, the electrical resistance of the resultant suspension is reduced. Therefore, as mixing continues, resistance continues to drop to the point where additional mixing will have no additional effect. At this point, the xGnP® is dispersed as well as possible with the given system parameters. A simple measurement apparatus can be constructed with a section of 12 gauge ROMEX wire (used in residential wiring). Baring ~1/2 inch of wire on each end and cutting off the ground wire makes an inexpensive (disposable) probe. Place one end in the subject suspension and connect the other to a multimeter (resistance). Monitor the resistance (Ohms) during dispersion. When additional mixing does not further lower resistance, the dispersion is finished.

- **xGnP® Dispersion Stability:** While the presence of "edge chemistry" and/or the use of surfactants will increase the stability of a suspension, particles will fall out of suspension unless frozen in the host matrix. To prevent settling and re-agglomeration do not store the dispersion for long periods; react (or use) the suspension as soon as possible. Normally, particles that settle out of suspension can be re-dispersed.