



Maximize your productivity through
Skyspring nanomaterials

Graphene Nanopowder

Product Number: 0541DX

CAS Number: 7782-42-5

Empirical Formula: C

Details

Graphene Platelet Nanopowder

Appearance: Black powder

Morphology: platelet

Thickness: 6-8 nm

Average Particle Diameter: 15 micron

Surface Area: 120-150 m²/g

Content of Carbon: 99.5+%

Electrical Conductivity (siemens/meter):

10⁷ (parallel to surface), 10² (perpendicular to surface)

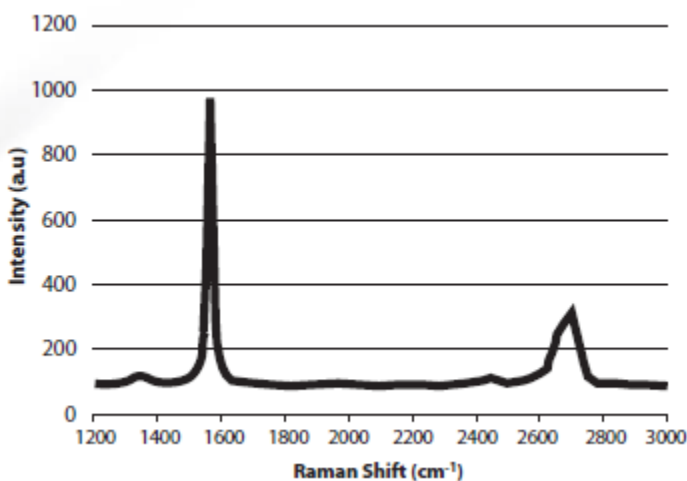
Thermal Conductivity (watts/meter-K):

3000 (parallel to surface), 6 (perpendicular to surface)

Thermal Expansion (M/M/deg.-K):

4-6x10⁻⁶ (parallel to surface), 0.5-1.0x10⁻⁶ (perpendicular to surface)

Raman Spectroscopy of product 0541DX:



For dispersion note and related products, please check product webpage:

<http://www.ssnano.com/inc/sdetail/3368>

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Dispersion Notes for Graphene Nanopowders- Products 0541DX and 0544DX

General

Graphene Nanopowders, product 0541DX or 0544DX, are very thin, (5 – 10 nanometers in thickness) flat particles with quite large diameters. Like other nanoparticles, the small size gives rise to certain handling issues. Because of the flat shape of these particles, they are especially sensitive to van der Waals attractive forces and have a tendency to re-aggregate in the dry state. For this reason, we ship our nanopowder in a granular form. These granules are friable collections of individual particles that prevent agglomerations and are easily broken with mechanical agitation. Even though your material may appear to be agglomerated, and may contain large chunks of material, please consider that we have done a great deal of testing to determine that this is the most effective form of dry shipment for effective dispersion. We ship our material this way on purpose because we have found that this approach results in material that is most easily dispersed.

We have found that the untreated material disperses well in many polymer systems, but results will, of course, vary depending on the host system. In general, smaller particles disperse better than larger particles; dispersion is better in low viscosity materials, and surface-treatment can improve dispersion and/or adhesion with various resins. Also, once the particles are dispersed in a non-solid system, they will settle and possibly re-aggregate. The rate of settling will depend on whether a surface treatment is used and on the system's viscosity.

Below are hints to aid dispersion of product 0541DX or 0544DX into various systems.

Dispersion into Non-Aqueous Solvents

Organic solvents are very effective in obtaining a good dispersion but, in most cases, are not practical for our customer to use. Much of the early development work with product 0541DX or 0544DX in thermoplastic resins was done by dispersing the particles in an aromatic solvent, dissolving the polymer in the same solvent, mixing the two solutions and then evaporating the solvent to obtain the thermoplastic with an excellent dispersion of nanopowder.

Isopropanol (IPA) is a fairly good solvent which is inexpensive and easy to use, but may not be as effective as some stronger solvents. Some very effective solvents include N-methylpyrrolidone (NMP), dimethylformamide (DMF), tetrahydrofuran (THF), and chloroform. However, these are very strong and toxic materials and should be handled with great care by experienced personnel. In any case, if solvents are used to aid dispersion into a polymer system, care should be taken to make sure that the solvent is removed prior to further processing.

Dispersion into Aqueous Systems

Product 0541DX or 0544DX are hydrophobic and will not disperse in water without a dispersion aid. Three dispersion aids that we have proven to be useful are:

- Sodium dodecylbenzene sulfonate - (SDBS) – (solid)

- Linear or branched poly(ethyleneimine) - ((PEI) –(50% H₂O solution)
- Poly (sodium styrene sulfonate) – (PSS) – (~70k Mw, 30% H₂O solution)

Two methods have been used:

1. Add dispersant to water at 1-2% level and then add product 0541DX or 0544DX with the use of an ultrasonic mixer. The rate of product 0541DX or 0544DX addition to the liquid is critical. It should be added with continuous mixing, at a rate so that the product 0541DX or 0544DX does not coalesce on or in the liquid. A continuous feeding system (screw or vibratory) will be helpful. The addition rate may need to be adjusted during addition since the receiving liquid may change viscosity during this operation due to concentration and temperature changes. Careful product 0541DX or 0544DX addition should result in a stable suspension. Experimentation with the amount of dispersant will be necessary to determine the optimum level for your system.
2. Continue to sonicate the suspension from step for a few minutes or longer. Filter and wash the coated powders. Now re-disperse the coated product 0541DX or 0544DX in the desired amount of water to obtain a stable suspension.

In addition to the above solvents, a mixture of 15 wt% IPA to 85 wt% water should result in a carrier solution into which our nanopowders can be dispersed with the aid of sonication. Normally, particles that settle out of a solution can be redispersed with the aid of an ultrasonic probe.

Dispersion into Thermoplastic Matrix

While solvent dispersion will give the best results, it is not practical for volume production. Extrusion should yield good results, especially for lower viscosity thermoplastic resins, but 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.
- In general, mixing graphite nanopowders with powdered polymers, rather than pellets, result in better dispersion.
- Especially with resins in a powder format, it may be advisable to mix product 0541DX or 0544DX with powder before feeding into the extruder.
- Although feeding of pastes or liquids is not common, there may be special cases where a pre-dispersion of the nanopowders into a suitable carrier material could improve the results of the final composition. If the end use is in a polyolefin resin, the use of a pure hydrocarbon solvent would insure compatibility and a minimum of interference of any retained solvent in the final polyolefin properties

Dispersion into Thermoset Resin Matrix (Epoxy, Urethanes, etc)

For most resin systems, traditional mixing techniques should prove adequate. Sonication with an ultrasonic probe works well. Also, good results have been obtained with a high-shear 3 roll mill. A balance must be struck when using high shear mixing since prolonged use cause the particles to deform.

The rate of product 0541DX or 0544DX addition to the resin is critical. It should be added with continuous mixing, at a rate so that the 0541DX or 0544DX does not coalesce on or in the liquid. A continuous feeding system (screw or vibratory) will be helpful. The addition rate may need to be adjusted during addition since the receiving resin may change viscosity during this operation due to concentration and temperature changes. Careful product 0541DX or 0544DX addition should result in a stable suspension.

Do not store the dispersed blend for long periods since the powder will settle over time. The rate of settling is dependent on the viscosity of the subject resin. To prevent settling and re-agglomeration react the resin suspension as soon as possible. Normally, particles that settle out of a solution can be redispersed with the aid of an ultrasonic probe or other high-energy mixing system.



Safety Data Sheet

SkySpring Nanomaterials, Inc.

www.ssnano.com

Revision Date: 12/01/2015

1 Identification of substance:

- **Product details:**
- **Trade name:** Graphene Nanopowder
- **Product number:** 0540DX, 0541DX, 0544DX
- **Manufacturer/Supplier:**
SkySpring Nanomaterials, Inc.
2935 Westhollow Dr., Houston, TX 77082, USA
Phone: 281-870-1700, Fax: 281-870-8002,
Email: sales@ssnano.com

2 Composition/Data on components:

Material: Graphite
CAS No.: 7782-42-5, 100%
Physical appearance: a gray or black fine powder.
Elemental composition: >99.5% Carbon

3 Hazards identification

EMERGENCY OVERVIEW: THIS MATERIAL MAY BE AN IRRITANT TO EYES, SKIN OR RESPIRATORY TRACT.

Potential Health Effects:

Eyes – may cause eye irritation.

Skin – may cause skin irritation.

Respiratory tract/inhalation – may cause irritation.

Ingestion – not hazardous in normal industrial use circumstances.

Cancer – natural graphite may contain small amounts of impurities of 0% - 1% crystalline silica, which is listed as a Group 1 carcinogen by IARC and as a suspected human carcinogen by ACGIH. Inhalation of high concentrations of crystalline silica over prolonged periods of time has been linked to an increase in lung cancer. Inhalation of high concentrations of crystalline silica over prolonged periods of time may also cause silicosis. Inhalation of high concentrations of graphite dust over prolonged periods of time may cause pneumoconiosis.

Physical Hazards:

Graphite is electrically conductive. Care should be taken, therefore, to avoid accumulations of graphite dusts or powders in places where these accumulations could cause shorting of electrical switches, circuits or components.

4 First aid measures

General: In the case of prolonged irritation or other adverse effects, contact a physician.

Inhalation: Remove from exposure to fresh air. If breathing is difficult, administer oxygen. If breathing has stopped, begin artificial respiration immediately. Seek medical attention.

Eye contact: Flush eyes with water for 15 minutes.

Skin contact: Wash with soap and water.

Ingestion: Rinse mouth with water.

Clothing: contaminated clothing should be removed and washed thoroughly before re-use.

5 Fire fighting measures

In general, graphite is difficult to combust. Normal care should be taken to avoid dust explosion risk through high concentrations of dust or finely-suspended airborne particles, although graphite dust is not normally considered an explosion hazard.

Suitable Extinguishing Media: water, carbon dioxide, dry chemical powder or foam as appropriate for surroundings.

Other Combustion Hazards: in the event of combustion or thermal decomposition, this material may release carbon monoxide (CO) or carbon dioxide (CO₂) or other toxic gases. At temperatures over 300 °C. this material may react with potassium, sodium, rubidium, or cesium to create intercalation compounds that may ignite and may react explosively with water.

Protective Equipment: As with any fire, wear self-contained breathing apparatus and protective clothing to prevent contact with skin, eyes or lungs.

6 Accidental release measures

Spilled or released material should be collected mechanically and disposed of in suitable containers. Use care during cleanup to prevent the creation of concentrations of dust.

Personnel: Clean-up personnel should wear suitable protective equipment to prevent inhalation or skin contact. Cleanup personnel should beware of the risk of slippage due to the material's low coefficient of friction.

Environmental: Do not discharge into storm or sanitary sewers or groundwater.

7 Handling and storage

This material is stable at room temperature and does not pose a significant risk of combustion. This material should be stored in labeled, closed containers away from sources of ignition or heat. Care should be taken to avoid creating accumulations or concentrations of dust, since any dust can form a potentially explosive mixture in air. Graphite is electrically conductive. Care should be taken, therefore, to avoid accumulations of graphite dusts or powders in places where these accumulations could cause shorting of electrical switches, circuits or components.

Advice on Safe Handling: Provide good ventilation when handling. Personnel should take measures to avoid breathing dust created when handling and should wear suitable protective clothing to prevent skin and eye contact.

8 Exposure controls and personal protection

Exposure Guidelines

Graphite (CAS no. 7782-42-5) TWA:

ACGIH (TLV): 2.0 mg/m₃ respirable O

SHA (PEL): 15 ml/m₃ respirable

Crystalline Silica (CAS no. 14808-60-7) TWA:

ACGIH (TLV): 0.025 mg/m₃ respirable

OSHA (PEL): 10 mg/m₃ respirable

Personal Protective Equipment

Respiratory protection: Protect against inhalation. A respiratory protection program that meets applicable OSHA requirements should be maintained in the workplace.

Eye protection: Protect against contact with eyes by wearing suitable safety eyeglasses or chemical protective goggles or other face protection.

Skin protection: Protect against skin contact by wearing protective gloves. Protect against skin contact by wearing suitable clothing.

Engineering Controls

Provide adequate workplace ventilation. If dusts are generated through handling, local exhaust ventilation should be employed.

9 Physical and chemical properties:

Appearance: a gray or black powder

Odor: odorless

Melting point: approximately 3,600°C

Flash point: not applicable

Boiling point: not applicable

Vapor density: not applicable

Bulk density: .05 – 1.0 g/c₃

Solubility in water: negligible

Evaporation Rate: not applicable

Ignition temperature: dispersed dust cloud - >600°C, deposited dust - >365°C

10 Stability and reactivity

This material is stable.

Avoid contact with strong oxidizing agents, fluorine, or chlorine trifluoride.

There are no known hazardous decomposition products.

11 Toxicological information**Acute oral toxicity**

Graphite: LD₅₀ Rat > 2g/kg

Irritant effect on skin Graphite: non-irritant, rabbit, 4 hours exposure

Irritant effect on eyes Graphite: slight irritant, rabbit

Carcinogenicity This material may contain impurities of less than .5% crystalline silica, which is listed by IARC as a known human carcinogen and by ACGIH as A2 (suspected human carcinogen).

12 Ecological information:

Graphite is a naturally-occurring substance that is found throughout the world. It is not biodegradable. To our knowledge, there is no reliable data regarding its bioaccumulation or mobility in environmental media, nor is there reliable data to suggest that it should be considered an environmental hazard.

13 Disposal considerations

Dispose of in accordance with all local, state, or federal regulations.

14 Transport information

This material is not defined under US DOT, IMDG, GGVSee, or ICAO/IATA regulations as a hazardous substance. This material is not defined under Canadian Transport Dangerous Goods Directorate regulations as a hazardous substance.

15 Regulations

Graphite (CAS no. 7782-42-5) is not listed as a hazardous material under US Federal regulations. It is not listed under the Clean Air Act, the Clean Water Act, SARA (section 302, section 311/312, or section 313), HAPS, or IARC.

Graphite (CAS no. 7782-42-5) is listed on:

US: TCSA

Canada: DSL

EC: EINECS

This product has WHMIS (Canada) classification D2A

16 Other information:

Employers should use this information only as a supplement to other information gathered by them, and should make independent judgement of suitability of this information to ensure proper use and protect the health and safety of employees. This information is furnished without warranty, and any use of the product not in conformance with this Material Safety Data Sheet, or in combination with any other product or process, is the responsibility of the user.