

# Elicarb® Graphene Powder and Elicarb® Graphene Dispersion (AQ)

High quality graphene products from a reliable supply partner.

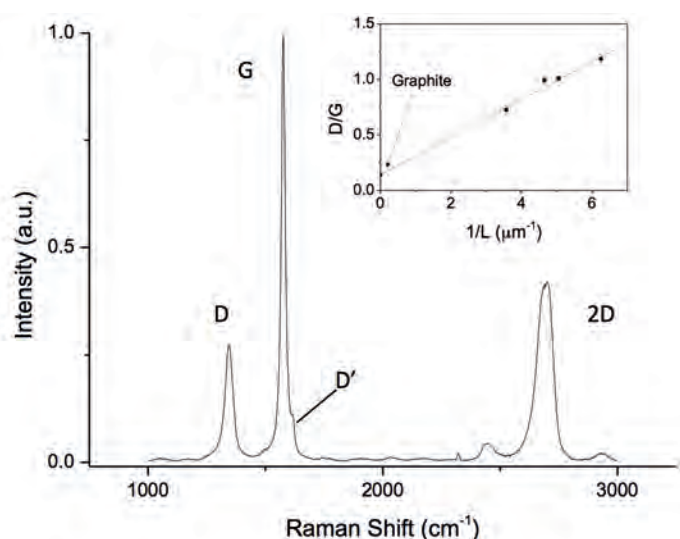
Thomas Swan is a world leader in the supply of Single Wall Carbon Nanotubes (SWNTs). We have a well-established manufacturing and supply capability in carbon nanomaterials which is underpinned by our position as an independent, international, performance and fine chemicals supplier.

In 2012, Thomas Swan announced a collaborative program with Professor Jonathan Coleman at CRANN (Centre for Research on Adaptive Nanostructures and Nanodevices) at Trinity College Dublin, Ireland. Working closely with CRANN a scalable, solvent exfoliation route to graphene from graphite raw material was developed. The approach builds upon the earlier research of Professor Coleman and as no aggressive intercalation or oxidative chemistry is employed the graphene product is substantially non-oxidised and defect free. Thomas Swan has exclusive manufacturing rights to this process and will manufacture and supply to global customers from 2014.

The advantages of using a “top-down” graphite exfoliation are

- Carbon sp<sup>2</sup> layers are substantially undamaged and non-oxidised.
- Contaminants of non-carbon elements such as oxygen (Hummers method) and metal catalyst residues are low.
- Particle size is uniform and in 0.5µm to 2.0µm range.
- Highly conductive Graphene Nanoplatelets (GNPs) are produced.

## Raman spectroscopy:



Raman spectra (532nm excitation wavelength) of Elicarb® Graphene Powder shows a high quality sp<sup>2</sup> carbon network with D/G ratio of 0.28 and D/D' of 5.0. Analysis of D/G ratio against flake size (inset) confirms that D-band is associated with plate edge effects rather than in-plane defects. The low D/D' ratio is also consistent with edge effects only. The 2D band shape indicates the presence of few-layer graphene flakes with an average of 5-7 atomic layers.

For additional information and pricing please contact:

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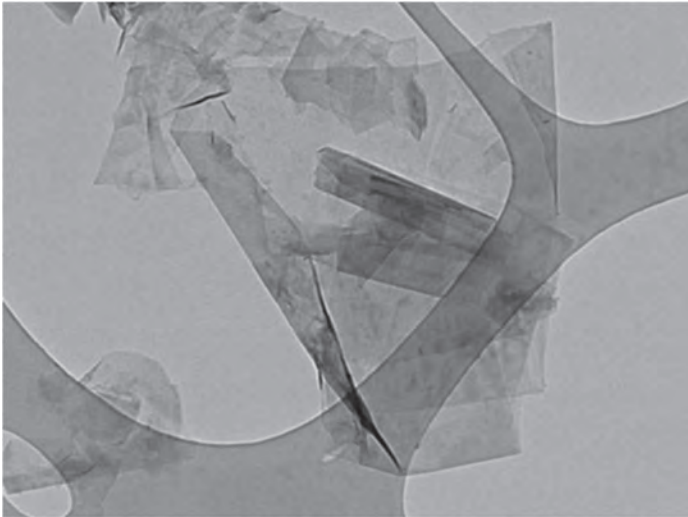
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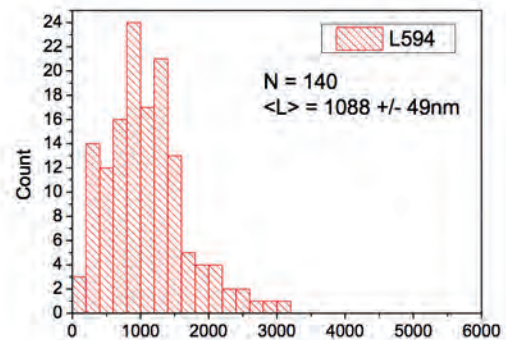
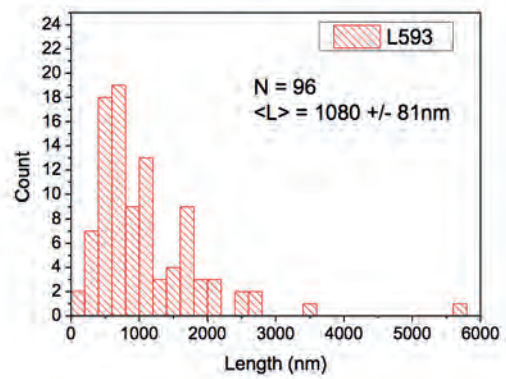


Committed to Responsible Care

## Platelet Size – Transmission Electron Microscopy (TEM):



TEM image of Elicarb® Graphene Powder (displayed on carbon grid) shows good quality GNPs of varying layer thicknesses.



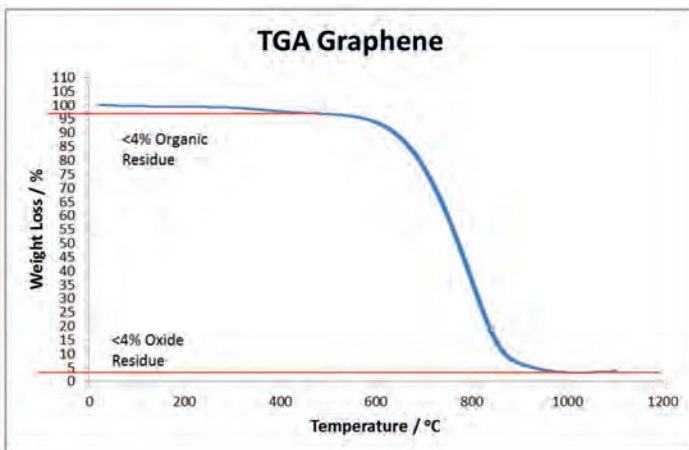
Number average platelet size of Elicarb® Graphene Powder by TEM image analysis shows an average X-Y platelet dimension of 1000nm. TEM analysis of multiple batches reveals excellent particle size repeatability from the exfoliation and extraction process.

## Sheet Resistance (4 point probe):

A test film is prepared by vacuum filtration of water dispersion of graphene to produce a ca 25 micron thick film. The film is not washed with further solvent after filtration. The sheet resistance is measured with the 4-point probe using on average 10mA current, the thickness of the film is measured to give a sheet resistance normalised to 25 micron.

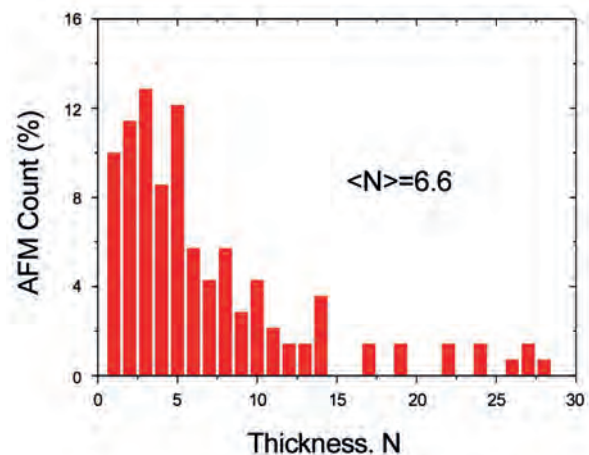
Typical Sheet Resistance is  $10 (\pm 5) \Omega/\square$  for a 25 $\mu\text{m}$  film.

## Thermogravimetric Analysis (in air):



TGA to 1100°C in air of Elicarb® Graphene Powder shows a weight loss of ca.4 % at 350°C which is decomposition of surfactant residues followed by the primary decomposition of graphene at 803°C. The manufacturing process can be tuned to reduce or eliminate surfactant residues. A final residue of ca. 4%/w remains at 1100°C which is due to inorganic residues within the graphite raw material.

## Platelet Thickness by Atomic Force Microscopy:



AFM analysis of mean thickness in NMP exfoliated GNPs shows an average plate thickness between 5 and 7 carbon layers.

Elicarb® Graphene products are high quality graphene nanoplatelets with consistent particle size and high conductivity.

Elicarb® Graphene is provided in two product formats:

**Elicarb® Graphene powder:**

GNP powder.

**Elicarb® Graphene Dispersion (AQ):**

A water/surfactant dispersed GNP at a concentration of 1g/litre.

### LIMITED WARRANTY INFORMATION:

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