GRAPHENE OXIDE

JMC

CREATING SWEETNESS AND PURE CHEMISTRY

Graphene-based Materials

Graphene-based materials continue to attract significant interest for use in a large variety of products ranging from microelectronics through to large scale applications such as cement and other composites. The properties of graphene-based materials are strongly influenced by the chemical purity of the materials as well as their physical properties.

Graphene oxide is typically soluble and more easily processed than pure graphene. In surface applications, graphene oxide can be deposited onto a substrate and then reduced to graphene. This method has been applied to products such as transparent electrodes and filters. Graphene oxide can though, be used directly in a range of applications where it can impart improved strength, thermal and electrical conductivity to composite materials.

Reduced Graphene Oxide

Graphene Oxide can be reduced to give reduced Graphene Oxide (rGO), a form of Graphene. Graphene is extremely strong and highly conductive, both electrically and thermally.

Functionalized Graphene Oxide

Graphene oxide is highly dispersable in water and alcohols due to its hydrophilic functional groups (-OH, -COOH). In order to develop a wide range of graphene oxide composites, high dispersability in organic solvents and polymer resins is desirable. By functionalizing graphene oxide with hydrophobic amine ($-NH_2$) groups, the dispersability of graphene oxide can be improved. In addition, the use of hydrophobic functional groups can enable the formation of hydrophobic surfaces.

Composites | Conductive Inks | Light-weight

Displays | Energy Electrodes | Heat Management

Available as powder or liquid

JMC Graphene Oxide Introduction

JMC's graphene oxide technology stems from our long history as a world-class chemical manufacturer. JMC manufactures the world's highest quality saccharin. We produce saccharin on a large scale using a completely vertically integrated process where we use sulfuric acid as an oxidising agent and our own raw materials. JMC's graphene oxide production begins with graphite and utilises the expertise that we have developed over the past 70 years.

JMC has developed processes to overcome some of the problems associated with the production of graphene oxide on a large scale. In particular, we have applied our expertise in quality assurance with a focus on controlling the lateral size of graphene oxide. This enables us to tune the graphene oxide properties to meet the requirements of a variety of applications. JMC also has extensive, large-scale waste water treatment facilities that enable us to scale the production of graphene oxide while complying with South Korea's strict safety and environmental regulations.

JMC's scalable Graphene Oxide production process can control the lateral size of graphene oxide particles from 10 to 40 micrometres while still achieving specifications of over 80% of the material being a single layer. JMC's rGO has an oxygen content below 2% and can also be made with large laterally-sized particles.

JMC is now positioned to sustainably produce graphene oxide on a large scale and is looking for partners to supply this material to.

Dispersed into composites

JMC Core Technology

>> Reaction : Control of exothermic reaction (using strong oxidants)
>> Product : Lateral size control, low metal and chloride content
>> Application : HVDC cable, batteries, radiation shielding, light-weight materials, composites, barrier films.

JMC Products

JMC Graphene Oxide Products

Product	Concentration	Particle Size (Lateral Size)	Mean
JGO-10	0.5–1.5%	< 10 μm	< 7 μm
JGO-05	0.5–1.5%	< 5 μm	< 3.5 μm

JMC Graphene Oxide Product Specifications

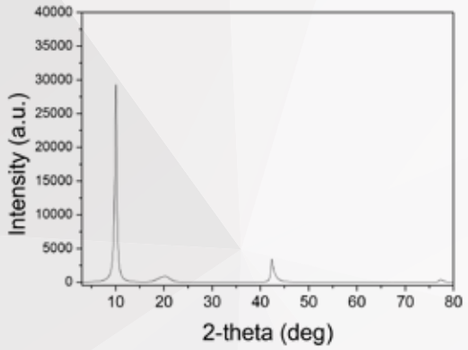
Subject	Unit	Spec.	Standard Sample	Test Method
Concentration	(%)	0.5–1.5	0.5–1.0	
Carbon content	(%)	40–50	43	EA
Oxygen content	(%)	40–50	44.7	EA
XRD 2θ value	(°)	9.5–10.5	9.80	XRD
Particle Size	(μm)	Selectable Size	< 10 μm, < 5 μm	FE SEM
Thickness	(nm)	≤2.0		AFM
K content	(ppm)	≤250		ICP - OES
Mn content	(ppm)	≤20		ICP - OES
Other metals	(ppm)	≤30		ICP - OES
Cl content	(%)	None		Titration
pH		3.0–5.0		pH Meter

JMC Special Grade Products (custom-made products)

Product	Product Features	Specifications
JGO-AF	Alkylamine-functionalized (Polymer and Organic Solvent Dispersion)	C6–C12 alkylamine surface treatmentPowder Carbon content ≥ 50% Nitrogen content ≤ 2%
JEGO	Partially Reduced Graphene Oxide	Carbon content 75~90% Nitrogen content 10~25%
JRGO	Reduced Graphene Oxide	Carbon content Min 98.0% Oxygen content Max 2.0%

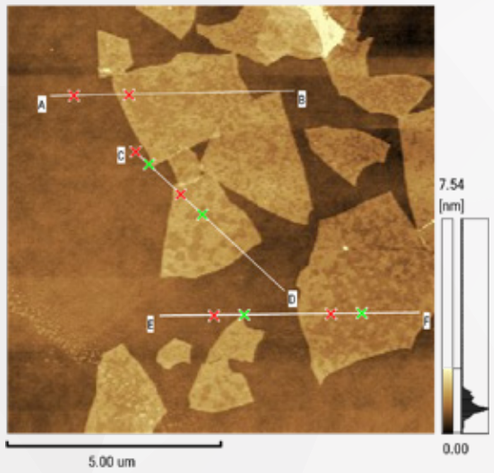
Product Analysis Data

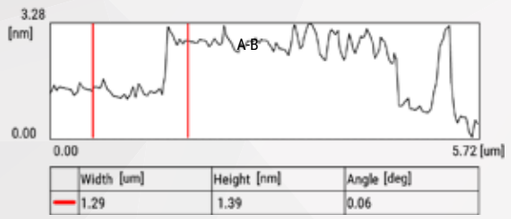
X-Ray Diffraction

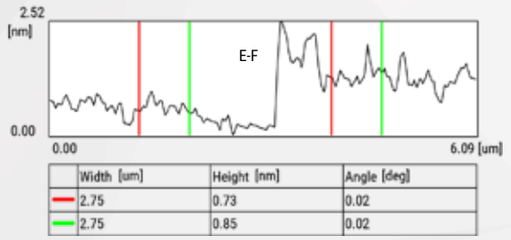


Defined Particle Size

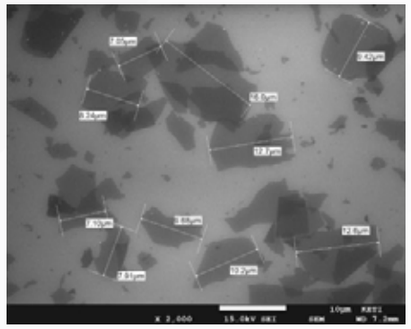
Atomic Force Microscopy





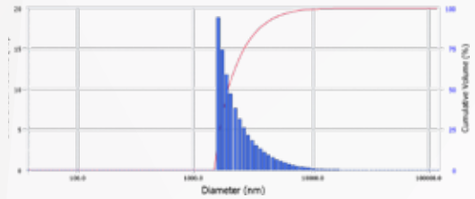


Particle Size Analysis



JGO-10
FE SEM

Volume Distribution



JGO-05

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Graphene Production. Quality and Sustainability.

Published November 2018 in Printed Electronics World

Printed Electronics World regularly covers developments in graphene-based materials. Reports have noted that "the market now accepts the diversity of graphene types and that **not all graphenes are equal.**" In this article, I will provide some perspective on the manufacture of graphene oxide with respect to **chemical purity and production sustainability**.

As a carbon-based material, **graphene is generally safe**. However, the manufacturing processes for various graphene-based materials can use hazardous materials such as acids, oxidizing and reducing agents. On a small scale, these chemicals are easily handled. However, **when graphene production is scaled the challenge of dealing with large quantities of reactive and corrosive materials is significant**.

Recently, thousands of chemical factories in China have faced shutdowns as part of a push to more strongly enforce environmental regulations. Factories producing dyes have been hit particularly hard as their processes typically use large quantities of hazardous materials. In some cases, these are exactly the same materials used for graphene manufacture.

An increased focus on safety is undoubtedly a good news story. Improved sustainability and reductions in hazardous materials benefits everyone, particularly those who work in and live near the factories that use these chemicals. However, this does stand as an important reminder for the emerging graphene industry that **reliable supplies will depend on companies building production facilities that can deal with reactive materials and waste on a large scale**.

JMC is an example of a chemical company that has built its reputation on the reliable supply of high quality materials. JMC's main product is saccharin, the artificial sweetener. **Saccharin is accepted as a safe additive to food, beverages, toothpastes, mouthwashes and pharmaceuticals** around the world. JMC's saccharin production facility, in South Korea, handles large quantities of reactive materials every day and has quality controls that ensure that **JMC's saccharin is the highest quality in the world**.

JMC has recently worked with Dr Yang at the Korea Electronics Technology Institute (KETI) to develop a **cost-effective scale-up scheme for the production of graphene oxide and reduced graphene oxide**, utilizing expertise in effective handling of acids and regeneration of oxidizing agents. Notably, **rather than being a start-up promising scale, JMC is an established chemical company** with demonstrated capacity to produce thousands of tonnes per year of high purity materials.

JMC is also part of the KISCO group which has deep experience producing ultra-high purity materials for electronics. JMC is also collaborating with KETI on other applications such as polymer-graphene oxide composites and materials for barrier films and displays.

JMC's entry into the graphene-based materials market is a signal that established chemical companies now see graphene as a viable market. This should help to provide the industry with greater certainty around the reliability and consistency of supply. JMC has already identified processes that enable the production of graphene oxide with a range of particle sizes.

JMC is also working closely with Professor Joo from Cornell University to further develop processes and identify potential applications for graphene oxide. Professor Joo will be speaking at IDTechEX on tailoring the folding and stacking of graphene oxide via scalable processes. Professor Joo will discuss results on using gas-assisted electrospinning to tailor the folding of large-sized graphene oxide sheets. These networks can then accommodate the volume expansion of silicon nanoparticles in batteries or be completely flattened to give a conformal coating for applications in corrosion prevention.

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https://www.printedelectronicsworld.com/articles/15551/graphene-production-quality-and-sustainability

Graphene Production. Controlling lateral size.

Published March 2019 in Printed Electronics World

Graphene-based materials continue to attract significant interest for use in a large variety of products ranging from microelectronics through to large scale applications such as cement and other composites. The properties of graphene-based materials are strongly influenced by the chemical purity of the materials as well as their physical properties.

Graphene oxide is typically soluble and more easily processed than pure graphene. In surface applications, graphene oxide can be deposited onto a substrate and then reduced to graphene. This method has been applied to products such as transparent electrodes and filters. **Graphene oxide can though, be used directly in a range of applications where it can impart improved strength, thermal and electrical conductivity** to composite materials.

In each application the **purity and physical properties of the graphene-based material have a major influence on performance and processing settings**. A key factor in the latter is the lateral size of the graphene oxide particles. Currently, most graphene oxide particles available in the market are less than 10 micrometres in size. It has generally proven difficult to make larger particle sizes.

Recently, **JMC, a leading Korean fine chemical manufacturer, has developed a large scale process to enable graphene oxide to be manufactured in a variety of sizes**. JMC's scalable process can control the **lateral size of graphene oxide particles from 10 to 40 micrometres** while still achieving specifications of **over 80% of the material being a single layer**. It is expected that having a variety of sizes available to developers will accelerate the development of commercial applications of graphene oxide. Large area **graphene oxide is seen as particularly important in applications such as silicon-graphene oxide anode materials** for batteries and in moisture barriers.

The development of a large scale graphene oxide production capability has been based on **JMC's long history of fine chemical manufacturing**. JMC's main product is saccharin, the artificial sweetener. Saccharin is accepted as a safe additive to food, beverages, toothpastes, mouthwashes and pharmaceuticals around the world.

JMC's saccharin production facility, in South Korea, handles large quantities of reactive materials every day and has quality controls that ensure that **JMC's saccharin is the highest quality in the world**. JMC's saccharin production process is completely vertically integrated. It begins with sulfur so all intermediates are manufactured in-house on a scale of over 10 tonnes of final product per day. JMC is therefore an **established, large-scale chemical manufacturer that has developed a graphene oxide production capability using existing facilities rather than a start-up looking to scale.** In assessing true production potential, reliable and reproducible supply, and product quality, the **benefits of working with an established, large-scale manufacturer are considerable**.

JMC is also working closely with **Professor Joo from Cornell University** to further develop processes and identify potential applications for graphene oxide. Professor Joo will be speaking at IDTechEX on methods to stack graphene oxide via scalable processes. Professor Joo will discuss results on using **gas-assisted electrospinning to tailor the folding of large-sized graphene oxide sheets**. These networks can then accommodate the volume expansion of silicon nanoparticles in batteries or be completely flattened to give a conformal coating for applications in corrosion prevention.

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https://www.printedelectronicsworld.com/articles/16678/graphene-production-controlling-lateral-size

JMC

JMC (originally the Jeil Moolsan Company) was established in 1953 and is a world leader in the field of saccharin and sulfur-based fine chemicals. JMC became part of the KISCO group in 2004. JMC is a large-scale manufacturer of saccharin, a safe, artificial sweetener that enables a drastic reduction in sugar content. JMC supplies saccharin to the world's largest quality-oriented multinational food and medicine producers. JMC produces saccharin using the traditional Remsen and Fahlberg Process which was discovered in 1879. JMC is the only company that produces all of the high purity raw-materials for Saccharin such as OTSA (ortho-Toluenesulfonamide) on its own production lines. No organic solvents are used during the production process of Saccharin and JMC's complete, vertical integration ensures the highest purity materials which delivers the highest quality saccharin available. JMC's saccharin meets the food safety standard, FSSC 22000. JMC also produces fine chemicals for applications such as florescent pigments, pharmaceutical intermediates, electronics, plastics and agricultural products.

JMC has applied its existing expertise and developed the ability to mass-produce next-generation nanomaterial products such as graphene oxide. JMC is continuously working to become a world-leading company by understanding the needs of its customers.

Based in **Korea**, our business is **global**. JMC – creating sweetness and pure chemistry.

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