



With low oxygen content, high purity, and easy processing from organic solvents, our graphene is ready for a wide range of industrial uses.

PREMIUM Graphene

Reduced Graphene Oxide Product

Since its discovery more than a decade ago, graphene has attracted interest thanks to its unusual electrical, electronic, optical, and mechanical properties which opens the door for a wide range of technological applications. However, the production of functional graphene materials on a large scale has been challenging but Pimata has advanced its production technology where this is no longer true. Pimata offers graphene oxide and graphene products in different formulations that are designed to be customized for every kind of use. Because of this, Pimata's graphene products have the potential to revolutionize the graphene industry with applications in batteries, transparent conducting electrodes, functional inks, flexible displays, antistatic coatings, and RFID antennas to name but a few.

PRODUCT OVERVIEW

PREMIUM graphene has several advantages over graphene products currently available in the market. Experiments show that commercial graphene products are technically few to multilayered graphene platelets produced from the exfoliation of expanded graphite. As such, those products have limited surface area which is a critical parameter for most applications. Without the large surface area, graphene loses most of its properties and behaves just like graphite. Using proprietary methods, Pimata has developed a unique process for producing graphene that is truly single layer in nature. In addition, our graphene exhibits additional features such as low oxygen content, high purity, and easy processing from organic solvents. These features enable our graphene to be used in a wide range of applications including but not limited to:

- batteries,
- supercapacitors
- sensors
- conductive films
- transparent conducting electrodes
- electronics
- functional inks
- composites
- catalysis
- fuel cells
- lubricants
- anti-corrosion coatings
- antistatic coatings
- thermoelectric devices
- hydrogen storage
- water filtration
- environmental remediation
- RFID antennas
- structural materials



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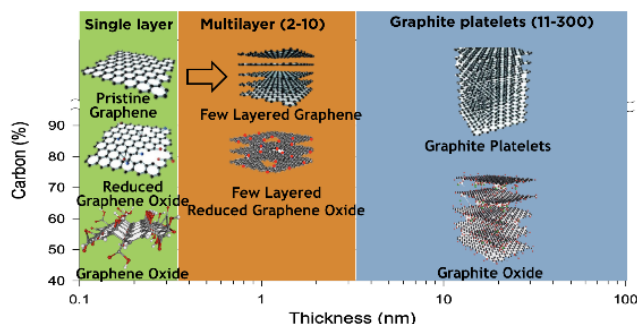
Product Specifications*

Appearance	Fluffy powder
Color	Black
Odor	Odorless
Manufacturing Method	Reduction of GO
Carbon Content (XPS)	85-91 at%
Oxygen Content (XPS)	8-15 at%
Ash	<1 at%
Solubility in Water	Insoluble
Dispersibility	Dispersible at low concentrations in ethylene glycol, ethanol, isopropanol, chloroform, DMF, NMP, THF, and dichlorobenzene
Surface Area - BET nitrogen	700 ±50 m ² /g
Electrical Conductivity	80±20 S/m
Apparent (tapped) density	0.002 - 0.005 g/cm ³
Particle Size Distribution of Bulk Powder ¹	D10: 6.99 µm; D50: 12.0 µm; D90: 19.5 µm
Lateral Size of rGO Flakes ²	D10: 0.19 µm; D50: 0.37 µm; D90: 0.69 µm

1. Conducted using a Horiba LA-960N laser scattering particle size analyzer.

2. Calculated using SEM of a rGO film casted from a rGO dispersion on a silicon wafer after a few minutes of probe ultra-sonication.

* All numbers listed in this sheet have been confirmed by third party testing and done according to the ISO standard: ISO_TS_21356-1_2021



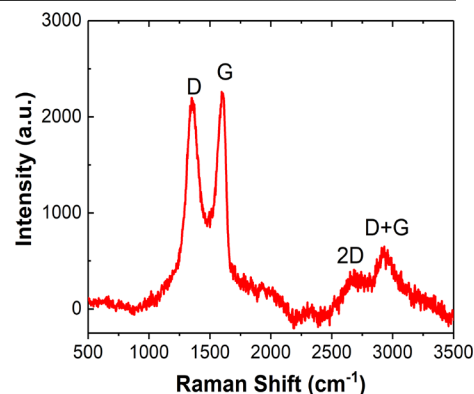
ELEMENTAL ANALYSIS

Carbon	70-80 wt%
Hydrogen	0-2 wt%
Nitrogen	<0.3 wt%
Oxygen	13-20 wt%

As shown from elemental analysis, the oxygen content of PREMIUM Graphene reduces to below 20 wt% from our effective reduction process from graphene oxide. At the same time, the impurity level keeps below 1%.

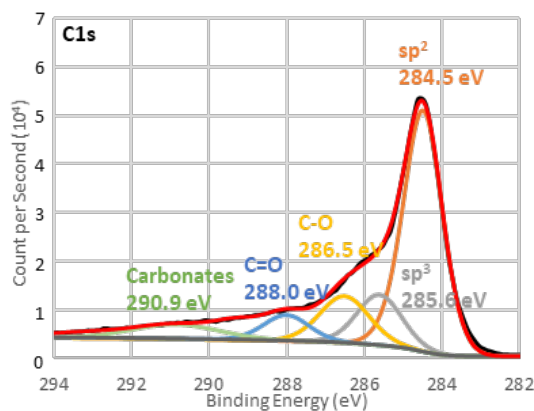
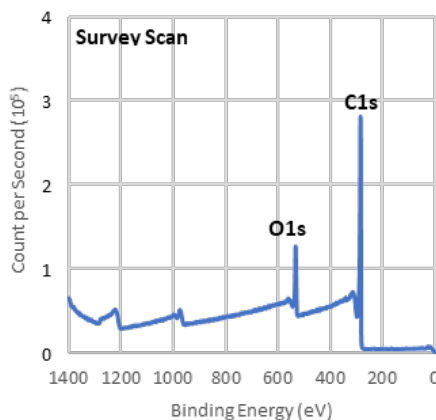
RAMAN ANALYSIS

The Raman spectrum of PREMIUM Graphene features the D band at 1350 cm^{-1} , the G band at 1580 cm^{-1} , the appearance of the 2D band at 2690 cm^{-1} and the D+G band at 2900 cm^{-1} after the reduction of GO verifying the recovery of sp^2 conjugation in PREMIUM Graphene.



XPS ANALYSIS

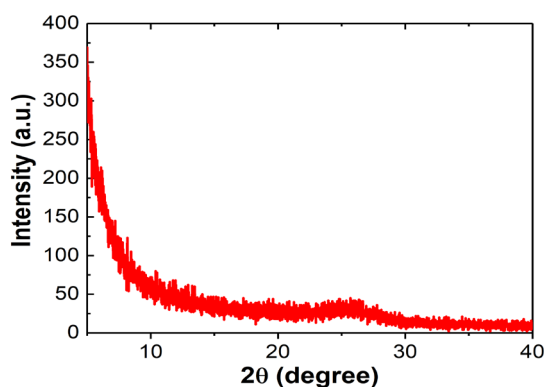
The effective reduction yielding PREMIUM Graphene is also confirmed from XPS analysis, showing low content of oxygen (10.2 at%) in comparison with high content of carbon (89.7 at%). The high-resolution C1s spectrum further demonstrates the dominance of sp^2 carbon (56.4%) compared to sp^3 carbon (12.8%), C-O (13.4%), C=O (6.6%), and O-C=O (7.3%).



C Species	Peak BE (eV)	Percentage (%)
sp^2	284.5	56.4
sp^3	285.6	12.8
C-O	286.5	13.4
C=O	288.0	6.6
O-C=O	290.9	7.3

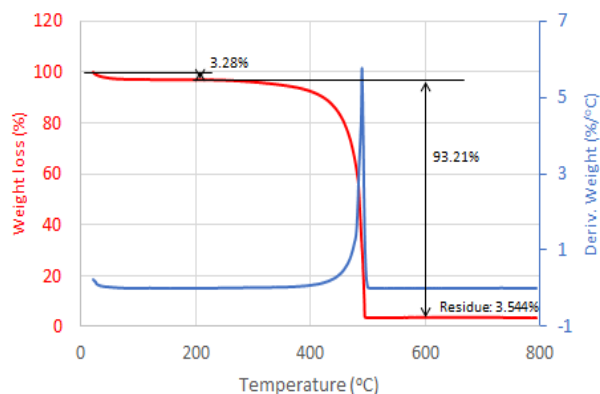
X-RAY DIFFRACTION

The powder XRD pattern of PREMIUM Graphene is almost featureless except for a weak and very broad hump from $\sim 22^\circ$ to 30° , confirming the exfoliated monolayer nature of the material.



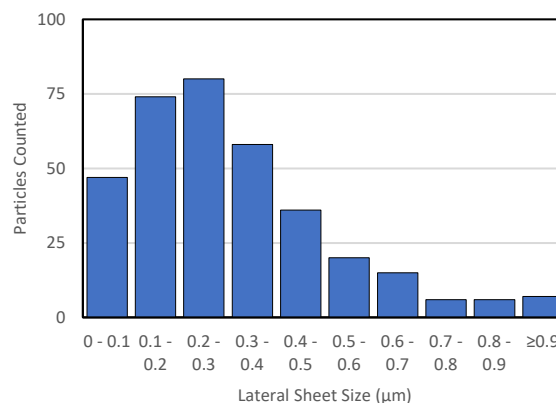
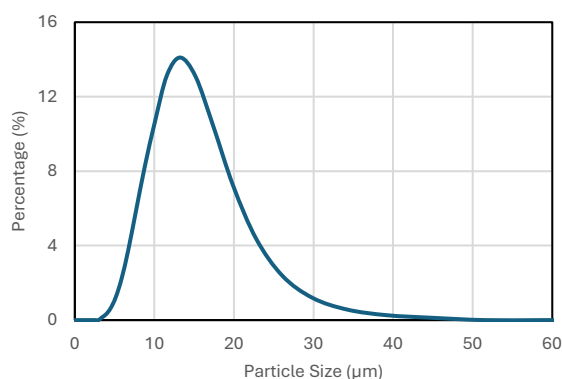
THERMAL ANALYSIS

PREMIUM Graphene is stable against heat in AIR up to 400 $^\circ\text{C}$, undergoing complete combustion at nearly 500 $^\circ\text{C}$.



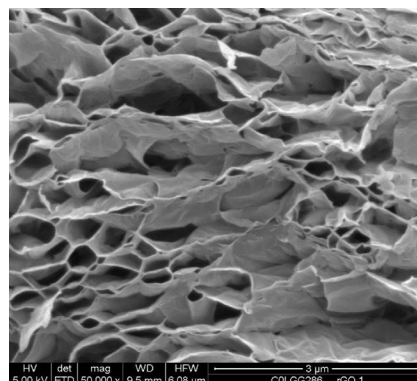
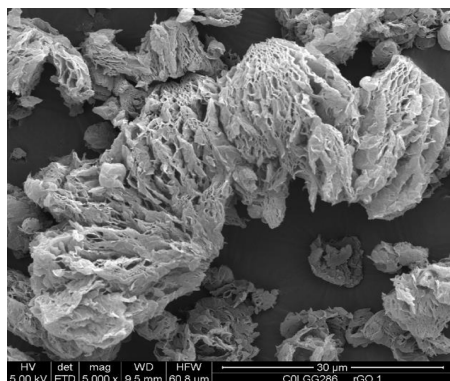
PARTICLE SIZE DISTRIBUTION

The particle size distribution of the PREMIUM Graphene bulk powder was measured using a Horiba LA-960N laser scattering particle size analyzer, showing D10 of 6.99 μm , D50 of 12.0 μm , and D90 of 19.5 μm . When dispersed into various polar solvents, PREMIUM Graphene can resume the individual nanosheet state and uniformly casted onto various substrates, exhibiting the flake size distribution with D10 of 0.19 μm , D50 of 0.37 μm , and D90 of 0.69 μm .



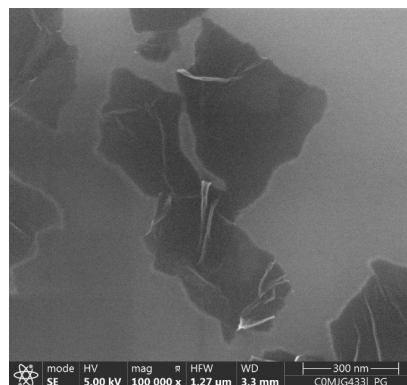
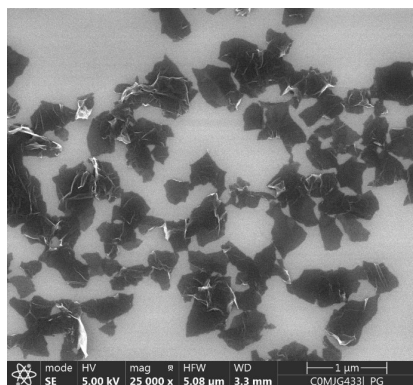
SEM IMAGING (BULK POWDER)

Under SEM, the bulk powder of PREMIUM Graphene exhibits a foam-like structure that is fully expanded and made of individual graphene nanosheets. The massive space between graphene sheets will facilitate the transportation of various substances and their interaction with graphene.



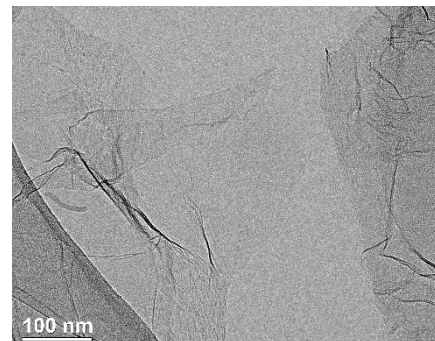
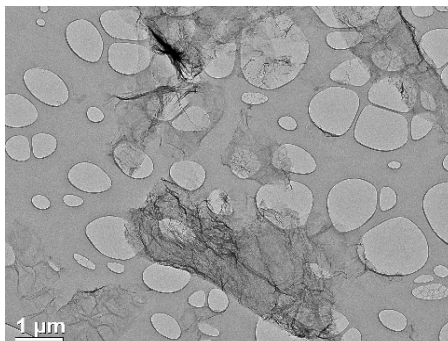
SEM IMAGING (DISPERSED NANOSHEETS)

After dispersing into solution, PREMIUM Graphene can be casted onto various substrates with little to no restacking due to the “unflatness” of the graphene nanosheets.



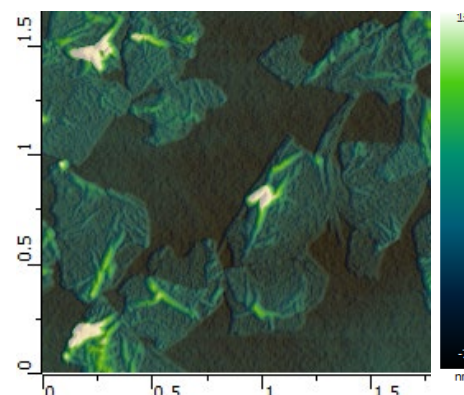
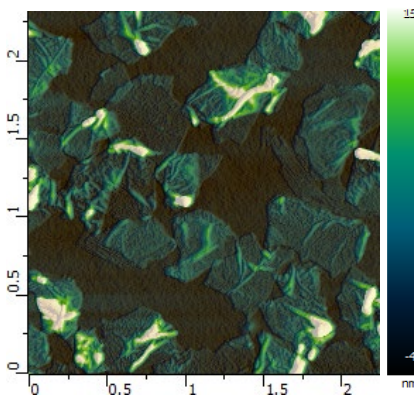
TEM IMAGING

TEM imaging of PREMIUM Graphene further proves the existence of massive wrinkles and rippling on the graphene basal plane. Thanks to these unique structure, PREMIUM Graphene can maintain the high surface area without restacking, preserving most active sites that could benefit for various applications.



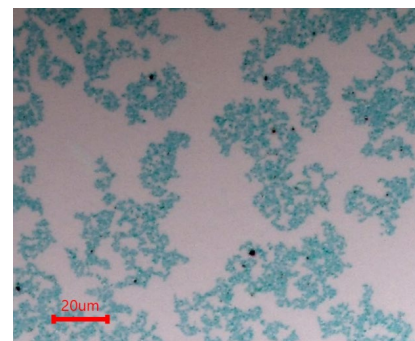
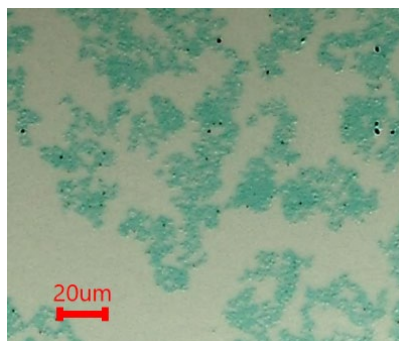
AFM IMAGING

AFM imaging of PREMIUM Graphene film deposited on a mica substrate confirms the single layer nature of PREMIUM Graphene. Especially, the AFM image shows the crumpling and wrinkles within the graphene sheet, which greatly contributes to its high surface area and minimum restacking.



OPTICAL MICROSCOPY

Optical microscopy and AFM of PREMIUM Graphene film deposited on a silicon wafer confirm the single layer nature of PREMIUM Graphene. Especially, the AFM image shows the crumpling and wrinkles within the graphene sheet, which greatly contributes to its high surface area and minimum restacking.



HOW TO DISPERSE GRAPHENE

Since graphene is hardly dispersible in any solvent medium, it is often used in its oxygenated form, the so-called graphene oxide (GO). Experiments show that PREMIUM Graphene (derived from the reduction of GO), still carries some oxygen-containing functionalities, which allows the dispersion of its sheets in a variety of polar solvents. PREMIUM Graphene can be dispersed in organic or aqueous solutions containing a surfactant by applying a mechanical force such as shear mixing, ultrasonic agitation or even ball milling. Solvents suitable for the dispersion of PREMIUM Graphene include ethylene glycol, ethanol, isopropanol, chloroform, DMF, NMP, THF, and dichlorobenzene. To get the best results, we recommend that our customers to disperse PREMIUM graphene powders using concentrations up to 0.5 mg/mL and probe sonicate or shear mix the solution for 15 minutes.



From left to right, dispersions of PREMIUM Graphene in ethylene glycol, ethanol, isopropanol, chloroform, DMF, NMP, THF, and dichlorobenzene at 0.1 mg/mL.

Disclaimer: The information claimed is believed to be accurate. Pimata holds no guarantee to the accuracy of data and no liability in connection with damages when using the product.

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