

REGOX® Graphene P995

REDUCED GRAPHENE OXIDE PREPARATION METHOD

LayerOne Medium Reduced Graphene Oxide (rGO) 95% C
is prepared by thermal reduction (flashing) of GO powder.

PHYSICAL PROPERTIES

Materials property	Analytical method	Value / test result
Appearance (form)	-	Powder
Appearance (color)	-	Black
Reduced Graphene Oxide	Gravimetric	> 99 %
Water		0-1 %
HCl	Estimated	< 1 %
Bulk density	Weight	0.008-0.01 g / cm ³
pH	pH-meter	About 3 when suspension in water and diluted to 0.1 weight %
Smell	-	Almost odorless
rGO-layers in sheet-stacks	SEM and BET	Average 6-7 layers*
Dispersibility	Sedimentation test	Cannot be truly dispersed in any medium. Fairly well dispersed in water / isopropanol mixtures. See instructions on last page.

*According to XRD and Raman Analysis

COMPOSITION AND CHEMICAL PROPERTIES

Materials property	Analytical method	Value / test result
Primary sheet thickness	XRD - Braggs equation	~ 0.34 nm
Crystallinity	XRD - Peak intensity	Broad peak around 26-27 deg 2θ
Crystalline phase	XRD - EVA	>99 % Reduced Graphene Oxide
Primary sheet aspect ratio	AFM - Visual	N/A
Crystallinity	TEM	N/A
BET surface area	BET measurement	350-400 m ² / g
Chemical composition (at%): Carbon	XPS	94 - 98 %
Oxygen	XPS	1 - 2 %
Sulfur	XPS	< 0.5 %, typically 0.2 %
Nitrogen	XPS	Not detected
Chlorine	XPS	< 0.5 %, typically 0.2 %
Metals	XPS	Not detected
C/O ratio (atomic ratio)	XPS	50-95

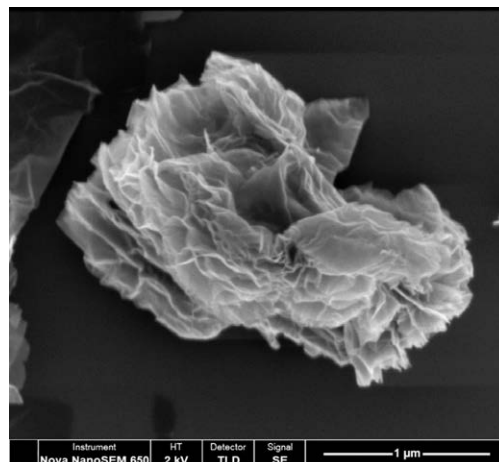
BACKGROUND DATA

LayerOne reduced Graphene Oxide (rGO) is produced by thermal reduction of graphene oxide. The product has been extensively analyzed, comprising SEM, XRD, IR, Raman, XPS and BET. For most analyses, data can be provided upon request.

SCANNING ELECTRON MICROSCOPY (SEM)

rGO powders were evaluated by a scanning electron microscopy (Nova NanoSEM650) with either secondary (SE) or backscattered (BSE) electrons at an accelerating voltage of 2 kV with magnification of 50 000x.

All samples were previously metalized with a 20 nm thick gold layer deposited with a Polaron SC502 sputter coater.



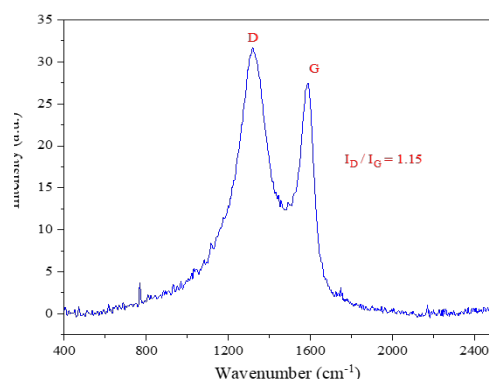
High resolution SEM of rGO powder showcasing the layered structure of the rGO particle.

RAMAN SPECTROSCOPY

Raman spectra were obtained with laser wavelengths of 532 nm and 390 nm and a spot size of 2 μm. The Si peak at 520 cm⁻¹ was used as a reference to calibrate the wave number.

The peaks at ~1320 cm⁻¹ (D band) and ~1590 cm⁻¹ (G band) that are commonly seen in the Raman spectra of carbonaceous materials are clear. The ratio of intensity of D/G bands is a measure of the defects present on graphene structure.

The ratio of the intensity of the D band to the G band (I_D/I_G) is calculated to be (i.e., ~1.15) for our rGO presenting low regime defect density.

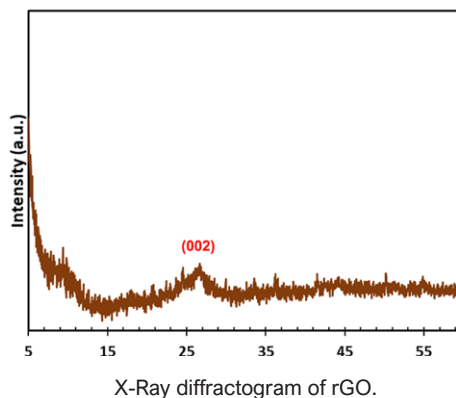


X-RAY DIFFRACTOMETRY (XRD)

X-ray diffractometry using CuKα radiation (angular interval 5–60° 2θ, and count time 4 s per step) was performed on rGO powder.

The broad peak at around 26° corresponds to the typical (002) diffraction peak of rGO.

The spacing between the RGO sheets is calculated to be around 0.34 nm.

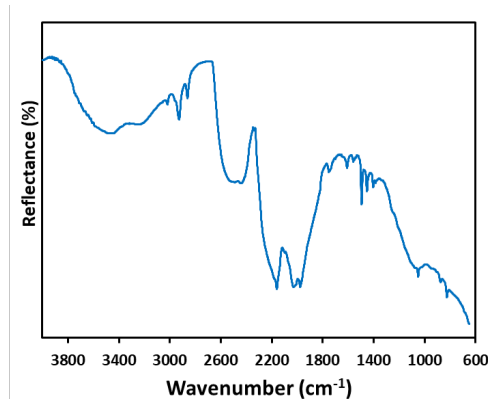


INFRARED SPECTROSCOPY (FTIR)

Fourier transform infrared (FTIR) spectroscopy was recorded with a PerkinElmer SpectrumOne spectrometer with an ATR attachment.

The functional groups detected by FTIR are listed in the table below.

Wave number (cm-1)	Functional group
800-1200	C-O
~1600	C=C
~1700	C=O
3000-3700	C-OH



IR spectrum of rGO

Instructions for safe use

Safety

- Read MSDS carefully before handling of product.
- The product is only for laboratory use by certified personnel.
- Use laboratory gloves. Use dust-mask.
- The powder is extremely light and will easily blow out of any container if exposed to draft, sneezing or the like.

Dispersion in liquid

True, stable dispersions cannot be prepared easily unless dispersing agents can be tolerated. Extended use of high shear and / or ultrasound is recommended. Semi-stable dispersions can be obtained in e.g. water/iso-propanol-mixtures. In oils and melted waxes fairly stable dispersions can be prepared by intense stirring.

Dispersion melted polymers

Can be added to melts but if automated feeder is used, we recommend using products 2.2 or 2.3. We recommend storing in cool and dry place.

Further reduction to fully reduced rGO

Thermal: Heat at 1100 deg C in flowing Ar-atmosphere for > 2 h.

Storage

Store in closed container. Shelf life is still not known. To our knowledge, the material does not degrade over time.

LayerOne takes no responsibility for the result of any mixing with or exposure to other substances!