Technical Data Sheet

Super Purified Plasma Nanotubes
(SPT-220 SWCNT)

''Using plasma, Raymor Nanotech provides high quality and purity SWCNTs on an industrial scale, rendering SWCNT based applications viable commercially.'' - Jacques Mallette: CEO

Summary

Using a patented plasma torch process, NanoIntegris, in conjunction with Raymor Nanotech, produces raw single-wall carbon nanotubes (SWCNTs) at high rates, enabling the lowest prices on the market. The plasma-grown SWCNTs display a high graphitization level, diameters (0.9-1.9 nm) and lengths (0.5-4 µm) close to those of laser- and arc-grown SWCNTs. The Super Purified Plasma Nanotube (SPT-220 SWCNT) product has a nanotube purity of **95-99%**. This material is provided in an aqueous surfactant solution with a nanotube concentration of 0.50 mg CNT/mL and a surfactant-removed thick film.

The following pages will display the information gathered by thermogravimetric analysis, Raman spectroscopy and optical absorption of the Super Purified Plasma Nanotube (SPT-220 SWCNT) product. A brief summary of the measurement protocols as well as a table showing our typical parameters will complete this technical data sheet.

Please visit www.nanointegris.com for more details on our prices and our technology.

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1. Super Purified Plasma Nanotubes (SPT-220 SWCNT): Optical Analysis

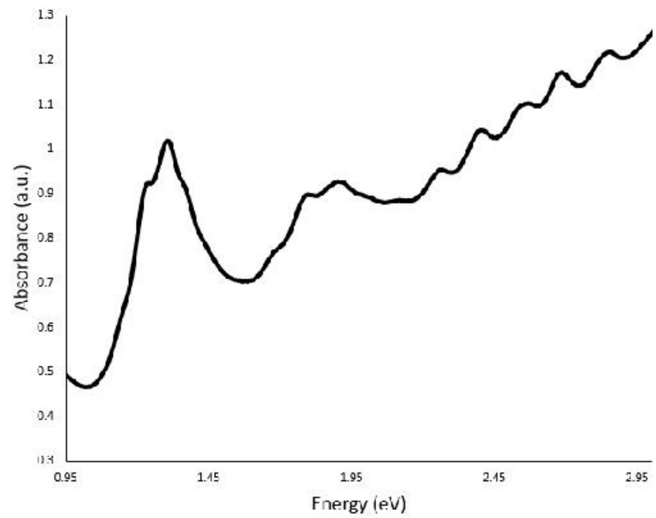

Figure 1. Optical absorbance of Super Purified Plasma Nanotubes SPT-220

Typical Parameter Ranges for Super Purified Plasma Nanotubes (SPT-220 SWCNT)

Parameter	Measurement	Typical Range
Itkis Index	Optical Absorption	0.26
Semiconducting Enrichment	Optical Absorption	75 - 78%
Metallic Enrichment	Optical Absorption	22 – 25%
Comparative Purification Efficacy (SPT-220 vs. RN-220)	Optical Absorption	325%

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2. Super Purified Plasma Nanotubes (SPT-220 SWCNT): Thermogravimetric Analysis

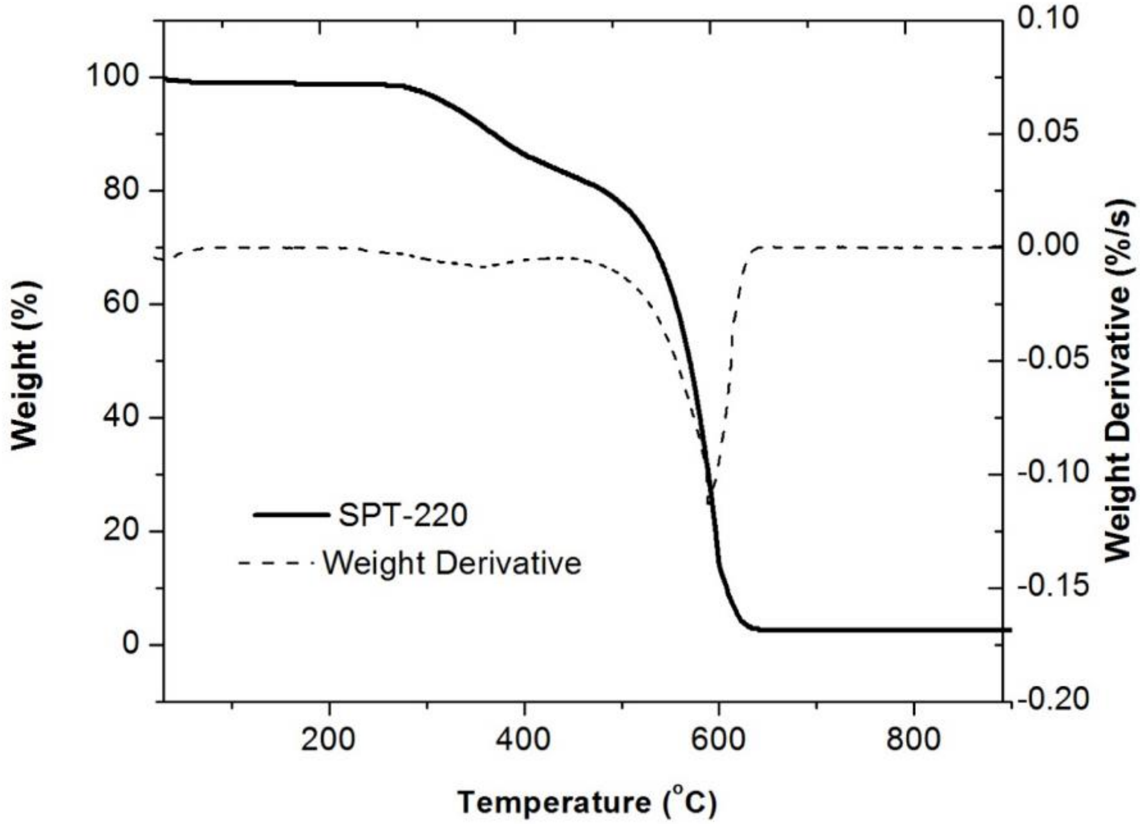

Figure 3.A. Thermogravimetric analysis plot of Super Purified Plasma Nanotubes

Typical Parameter Ranges for Super Purified Plasma Nanotubes (SPT-220 SWCNT)

Parameter	Measurement	Typical Range
Ash Content	Thermogravimetric analysis	2.32%
Metal Content	Thermogravimetric analysis	1.62%
1^{st} Oxidation peak	Thermogravimetric analysis	580 ^{o}C
2^{nd} Oxidation peak	Thermogravimetric analysis	650 ^{o}C

4. Super Purified Plasma Nanotubes (SPT-220 SWCNT): Raman Spectroscopy

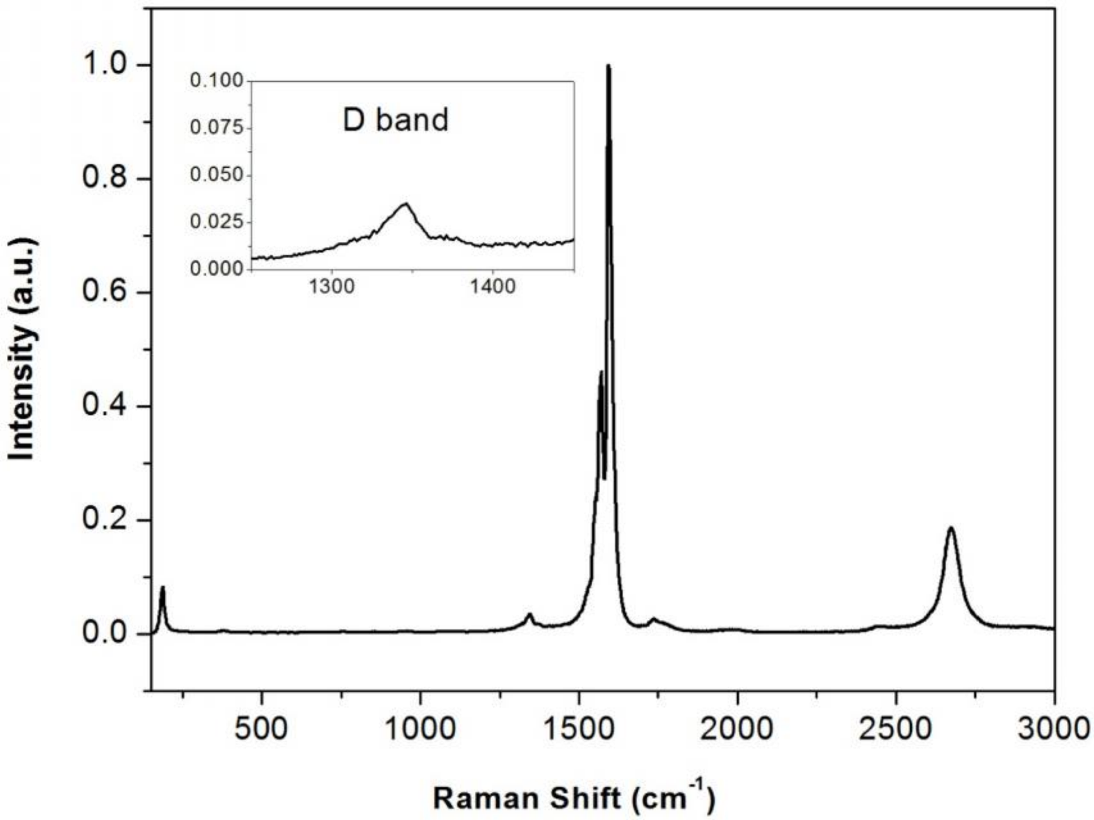

Figure 4.A. Raman Spectroscopy for Super Purified Plasma Nanotubes (SPT-220 SWCNT)

Typical Parameter Ranges for Super Purified Plasma Nanotubes (SPT-220 SWCNT)

Parameter	Measurement	Typical Range
G/D ratio with BWF subtraction	Raman Spectroscopy at 514nm	40
G/D ratio without BWF subtraction	Raman Spectroscopy at 514nm	34

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5. Methodology for Thermogravimetric Analysis (TGA)

For a typical TGA analysis, we place a 3-10 mg SWCNT sample into the properly calibrated TGA apparatus (Shimadzu). Using a slope of 10 ^{o}C/min, the temperature is raised from 0 to 900^{o}C in flowing air (18 cm^3).

The ash content is the lowest value of the weight curve that we read off where the curve is flat (between 800-900 ^{o}C). In order to determine the oxidation peaks, the TGA curve is smoothed with 150 data points. The derivative of the TGA is calculated with the TGA software and the oxidation peaks are the 2 minima of this derivative curve.

6. Methodology for Raman Spectroscopy

For Raman spectroscopy, the samples are prepared as follows: a 2 mg samples is homogenized in 1 ml of acetone using sonication during 1 min. The mixture is deposited onto a glass slide and the acetone dries. The samples are measured using Raman spectroscopy (Renishaw) at λ=514 nm with a calibrated laser power (typically 35 mW).

The laser beam diameter at the focal point is 120 µm. Before we calculate the G/D ratio, the constant baseline is subtracted from the Raman spectra.

To calculate the G/D more accurately, the Breit-Wigner-Fano profile, a contribution from the G band, is subtracted to obtain the height of the D band. This procedure leads to lower D band heights and higher G/D ratios. However, subtracting the Breit-Wigner-Fano (BWF) profile leads to some uncertainty because it is difficult to model this profile accurately.

7. Methodology for Optical Absorption

For optical absorption measurements two different approaches are incorporated:

a. Powder-form: <1 mg of SWCNT is dispersed in 20 ml of DMF using sonication (2 minutes of sonication with 600W at 12% with 1/8 inch tip). Using further dilution and sonication cycles, we calibrate the SWCNT concentration in the DMF such that the absorbance at 800 nm is between 0.1 and 0.3.
b. Solution-form: An aqueous 2% surfactant solution is used to dilute the concentrated product to a CNT concentration between 0.01 and 0.02 mg/ml. This allows the maximal peak absorbance to be in the range of 0.4 to 1.0 absorbance units to satisfy the Beer-Lambert law.

All optical absorbance measurements are made in a double beam UV-vis-NIR spectrophotometer (CARY 5000). To calculate the Itkis index, the π-plasmon and metallic SWCNT contribution to the background (below the S_{22} band) are modeled as a straight line (between 1-3 eV). Once this background is subtracted, we integrate the area of the S_{22} band between 1.1 and 1.55 eV. The band area is divided by the total absorption (including the background) between 1.1 and 1.55 eV to yield the Itkis index.

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