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SWNT Typical Properties and Quality Parameters

Single-walled Carbon Nanotubes

Products: SG65, SG76 and CG100
Store at Room Temperature
Technical Bulletin SWNT-001

TECHNICAL BULLETIN

Synonyms: SWCNT; SWNT

Product Description
These SWCNT products are produced by a CoMoCAT® catalytic CVD process, using a flow of pure carbon monoxide (CO) at a pressure of 1–10 atm. The nanotubes are grown by CO disproportionation (decomposition into C and CO_2) at 700–950 °C in the presence of a unique Co-Mo catalyst.

Quality Parameters

1. T1% and Residual Mass from Thermogravimetric (TGA) Analysis - Thermogravimetric analysis is used to assess the purity of the material. The quality parameters determined from the TGA analysis are T1% and Residual mass at 625 °C. A typical TGA for a SWCNT is shown in Figure 1. Studies have shown that the first peak in the derivative curve represents the oxidation of SWCNT, while the second peak is indicative of the presence of other forms of carbon.

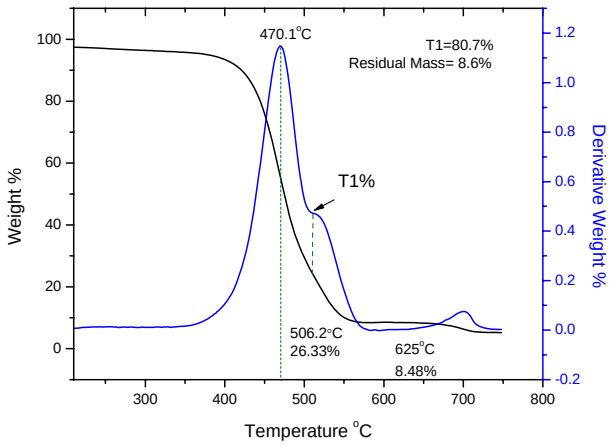
T1%, as shown in Figure 1, is measured as a control parameter. It has been shown that this measurement typically underestimates the SWCNT content by 3–5%. The position for T1 is taken at the minimum between the two peaks in the derivative curve. In the absence of a second distinct peak in the derivative curve, T1 is taken at the point of inflection. The weight loss % is recorded and the final value of T1% as a percentage of the carbon in the sample, corrected for the initial weight loss due to moisture in the sample is calculated from the following equation:

$$T1\% = \frac{\text{Initial weight} - \text{T1\% measured}}{\text{Initial weight} - \text{residual mass}}$$

The measurement of residual mass at 625 °C gives a measure of the non-carbon content of the material. The residual mass is expressed as a percentage normalized for the weight loss at 200 °C.

$$\text{Residual Mass} = \frac{\text{Weight Loss at 625 °C}}{\text{Initial Weight Loss}}$$

Figure 1. Thermogravimetric (TGA) Analysis for **SG65**

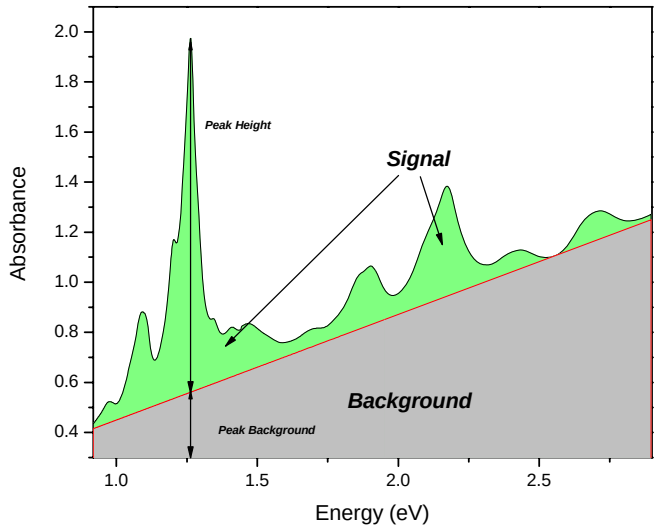


The small peak in the derivative curve above 625 °C is due to changes in the residual catalyst as the material is heated.

2. P2B from Optical Absorbance Spectrum - P2B is measured from the optical absorbance spectrum to ensure chirality control and applies to products **SG 65** and **SG 76** only. P2B is defined as the height of the highest peak in the spectrum between 350 and 1,350 nm divided by the background at that wavelength. Figure 2 shows a typical spectrum for product **SG 65** with the abscissa transformed to the energy domain. This results in a linear background over the range of the spectrum.

   P2B = $\frac{\text{Height of (6,5) or (7,6) Signal Peak}}{\text{Height of Background Peak}}$

Figure 2. Optical Absorbance Spectrum for **SG 65**



For **SG 65** the highest peak corresponds to (6,5) tubes. For **SG 76** the highest peak corresponds to (7,6) tubes

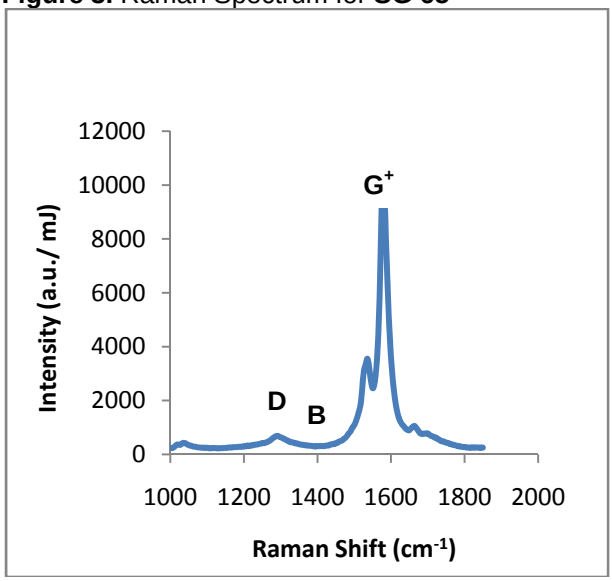
3. The Raman Quality Factor (Q) is a measure of overall quality and particularly indicative of the level of amorphous carbon relative to that of carbon nanotubes (see Figure 3).

   The Raman Quality Factor is defined as:

   $Q = 1 - \frac{(D - B)}{(G - B)}$

   Where:
   D = maximum height of D band
   G = maximum height of G^+ band
   B = baseline, lowest point between the two bands

Figure 3. Raman Spectrum for **SG 65**



Spectrum obtained with 633 nm laser.

Table 1.
Properties of Single-walled Carbon Nanotube Products

Property	**CG 100**	**SG 65**	**Sg 76**
Tube diameter[1] (nm)	1.0 ± 0.3	0.8 ± 0.1	0.9 ± 0.2
Tube length[2] (nm)			
Mode	800	900	800
Range	400–2,300	450–2,000	300–2,300
Carbon content[3]	>90%	>90%	>90%
SWCNT content[4] (% carbon as SWCNT)	75%	80%	80%
Chirality Distribution[5]	–	>50% (6,5)	>50% (7,6)
Aspect ratio	1,000	1,000	1,000
Data available upon request for each lot	UV-Vis-NIR, Raman, TGA		

[1] Tube diameter determined from optical absorbance and AFM.
[2] Tube length determined from AFM.
[3] Carbon content determined from TGA spectrum.
[4] SWCNT content is equivalent to T1% determined from TGA spectrum.
[5] Chirality distribution is equivalent to P2B determined from the optical absorbance spectrum.

Precautions and Disclaimer
This product is for R&D use only, not for drug, household, or other uses. Please consult the Material Safety Data Sheet for information regarding hazards and safe handling practices.

Storage/Stability
Store the nanotubes at room temperature.

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