SHIMADZU APPLICATION NEWS

LAAN-A-UV-E009

● SPECTROPHOTOMETRIC ANALYSIS

No.A386

Introduction of UV-VIS-NIR Spectrophotometer UV-3600, which Uses Three Detectors to Provide High Sensitivity in All Near-Infrared Regions.

This News Bulletin Mainly Introduces Measured Data of Carbon-Nanotubes.

Equipped with a photomultiplier, a cooled PbS detector, and an InGaAs detector, the UV-3600 (Fig. 1) is a multi-detector spectrophotometer which, by using the cooled PbS detector and the InGaAs detector in the near infrared region, has achieved high sensitivity in all regions.

This issue introduces measured data conducted using carbon-nanotubes, which continue to gain in popularity.

■ Three Detectors Provide High Sensitivity

Conventional UV-VIS-NIR spectrophotometers have come to employ photomultipliers for the UV-VIS region and PbS detectors for the near infrared region. This configuration resulted in insufficient sensitivity in the 800 nm – 1200 nm region, where the sensitivity of both of these detectors is decreased. By attaching an InGaAs detector, the UV-3600 achieves a high level of sensitivity in that region (Fig.2).

Fig.3 shows the transmittance spectrum of quartz glass with no OH group while Fig.4 shows the transmittance spectrum of quartz glass with an OH group. An excellent low-noise spectrum is achieved across the entire 185 – 3300 nm measurement region. In Fig.4, OH group absorption at 2700 nm and 2200 nm is clearly visible.

Fig.1 UV-VIS-NIR Spectrophotometer UV-3600

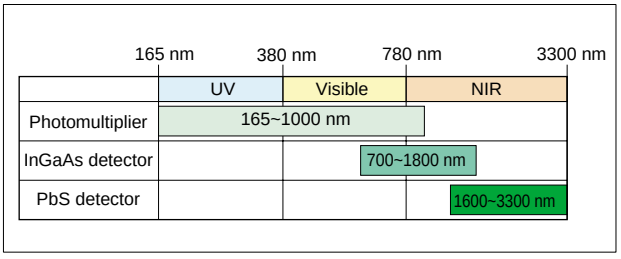

Fig.2 Wavelength Region Covered by Each Three Detectors

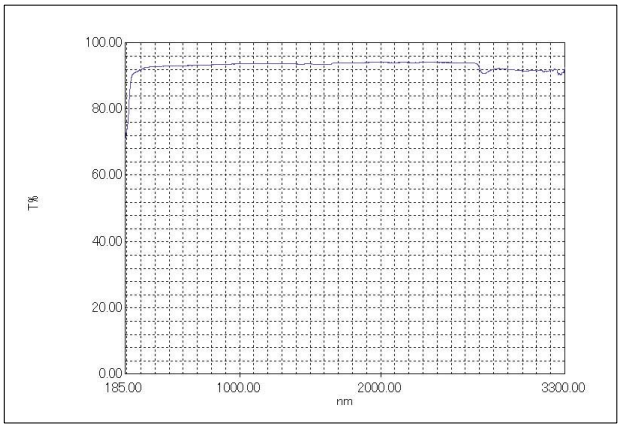

Fig.3 Transmittance Spectrum of Quartz with No OH Group

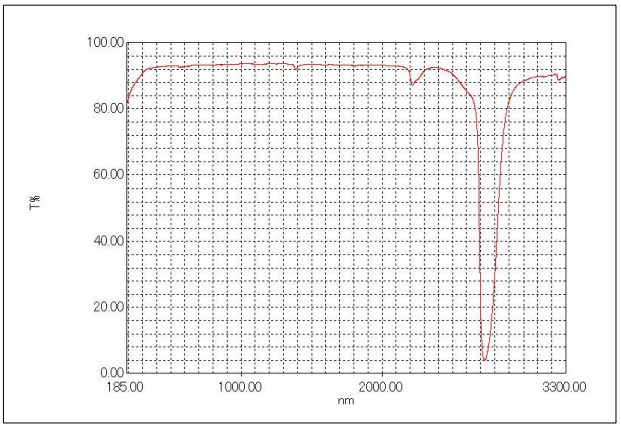

Fig.4 Transmittance Spectrum of Quartz with OH Group

■ Measurement of Carbon Nanotubes

The UV-3600 was used to measure a dispersed carbon nanotube (CNT) in liquid form and the dried and hardened form of the liquid CNT. The CNT used in these measurements was a SWNT (single-walled nanotube), which has a single layer structure.

The dispersed liquid was prepared by dissolving a small amount of powder CNT in 20 mL of a 1% sodium cholate solution and applying ultrasound for 1 hour before placing in a centrifugal separator at 10000G for 15 minutes. The supernatant liquid was then collected and used as the sample. For the blank, we used a 1% sodium cholate solution. Using the 2 mm long quartz cell, the results of the absorption spectrum measurement in the visible and near infrared regions are shown in Fig.5.

For the dried sample, an amount of the abovementioned supernatant liquid was dropped onto a 4 cmϕ quartz glass and allowed to dry after which we measured the thin substance that formed on the surface. Only the quartz glass was used as a blank. Results of the measurement are shown in Fig.6. As this measurement is based on diffused transmittance, the measurement was conducted using an integrating sphere. Fig.7 shows an overwriting of both spectra data.

In both sets of data, the peak unique to SWNT is present in the visible and near infrared regions. The small peak near 580 nm is equivalent to the M_1 absorption band, the peak near 820 nm to the S_2 absorption band, and the large peak near 1430 nm to the S_1 absorption band. These absorption bands all are related to the state of electron and this is used in the evaluation of CNT properties. M_1 indicates the SWNT's metallic properties while S_1 and S_2 indicate semiconductive properties. For example, by knowing the intensity ratios of M_1 and S_2, it is possible to learn the abundance ratios of metallic SWNTs and semiconductive SWNTs.

In recent years, near infrared measurement has become popular as a quick method of conducting semi-quantitative measurement of general CNT sample information.

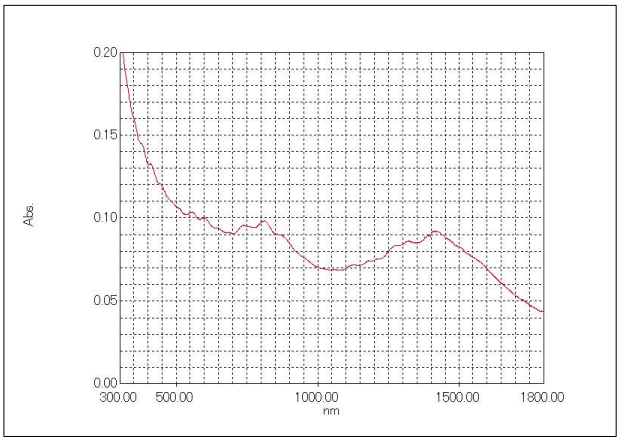

Fig.5 Absorption Spectrum of CNT Dispersed Solution

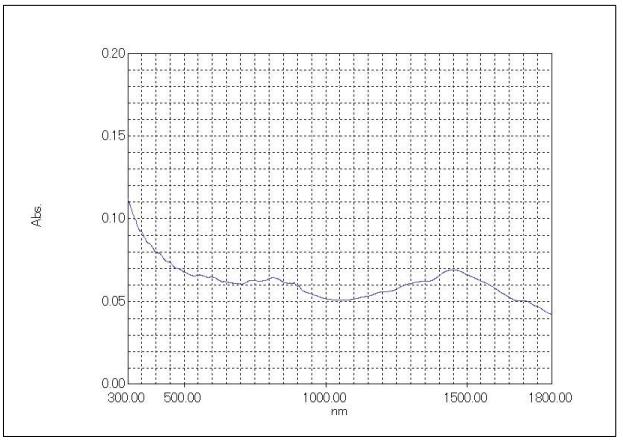

Fig.6 Absorption Spectrum of dried CNT Dispersed Solution

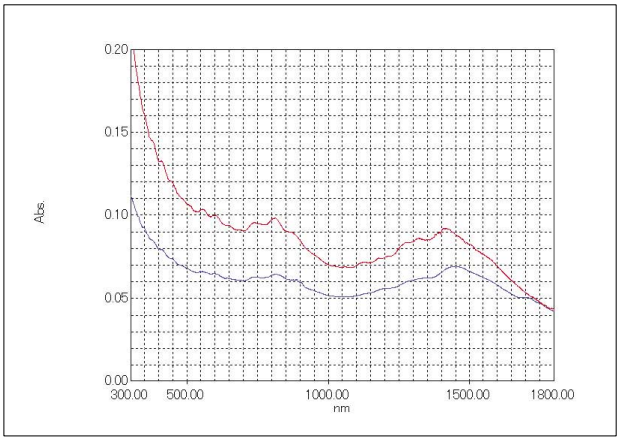

Fig.7 Overwriting of the Two Spectra

(References)

1. Solubilization of SWNTs by Cholic Acid and Deoxycholic Acid Micelle – Ayumi Ishibashi, Naotoshi Nakashima (28th Fullerene-Nanotubes General Symposium Seminar Overview Page. 194, 2005)
2. Introductory Materials Science of Carbon Nanotubes (Edited by Yahachi Saito, Corona Publishing)

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› UV-3600i Plus
UV-VIS-NIR Spectrophotometer

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