Spectrophotometric Analysis

Application News

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Example of Reflectance Measurement Using Integrating Sphere: Difference of Spectra Depending on White Reference Plate

An integrating sphere is generally used in measurements of the reflectance of samples which display scattering or diffuse reflectance, such as solids and cloudy liquids. An integrating sphere is spherical in shape with an inner wall made of barium sulfate or some other light-scattering material with high reflectance, and has the effect of causing light that enters the sphere (measurement light) to scatter uniformly. This enables highly accurate detection of transmitted light or reflected light from the sample, even when measuring samples with scattering properties.

Because the reflectance of samples obtained by measurements using an integrating sphere is a relative reflectance value obtained by comparison with the white reference plate as a standard, the obtained value depends on the reflectance of the white reference plate. Therefore, the measured reflectance of a sample may change if a different white reference plate is used, or if the reflectance of the white reference plate changes due to deterioration, even when using the same plate.

Although pressed and solidified barium sulfate ($BaSO_4$) is generally used in white reference plates, other substances are also used, including aluminum oxide (alumina, Al_2O_3) and magnesium oxide (MgO) powders or a fluoropolymer white reference plate with a specified reflectance.

This article introduces an example in which the reflection spectra of various samples were measured using a UV-3600i Plus ultraviolet-visible light-near infrared (UV-VIS-NIR) spectrophotometer and ISR-603 integrating sphere attachment in order to verify the effect on sample measurements in case barium sulfate and magnesium oxide powder reagents and a fluoropolymer white reference plate are used in the white reference plate.

A. Goto

Difference in Reflectance of White Reference Plates

$BaSO_4$ and MgO powder reagents were filled in powder sample holders, as shown in Fig. 1. White reference plates made of these powder reagents are inexpensive and can be replaced if soiled, but their reflectance may differ depending on the filling method. On the other hand, fluoropolymer white reference plates are expensive but have the merits of displaying uniform reflectance except when soiled and higher reflectance than other white reference plates, particularly in the near-infrared region. (When a fluoropolymer white reference plate is soiled, it is necessary to repolish the plate or purchase a new plate.) Details may be found in UV Talk Letter Vol. 12. In this article, the reflectance of $BaSO_4$ and MgO was measured using a fluoropolymer white reference plate as a standard in order to compare the reflectance characteristics of the respective white reference plates (Fig. 2). Table 1 shows the measurement conditions.

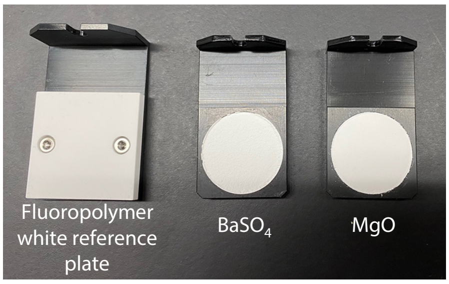

Fig. 1 White Reference Plates

Table 1 Measurement Conditions

Instruments	: UV-3600i Plus, ISR-603
Measurement mode	: Reflectance
Measurement wavelength range	: 250 - 2500 nm
Scan speed	: Medium
Sampling pitch	: 1.0 nm
Slit width	: (20) nm
Light source switching wavelength	: 310 nm
Detector switching wavelength	: 830 nm, 1650 nm

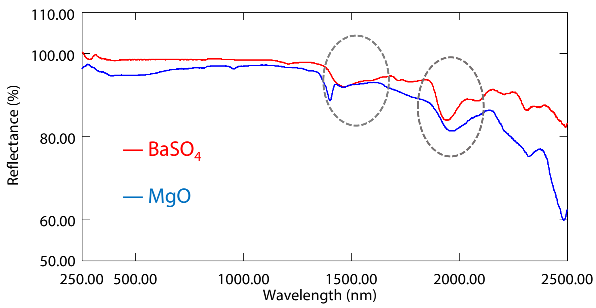

Fig. 2 Relative Reflectance Spectra of Samples (White Reference Plate: Fluoropolymer White Reference Plate)

Although both $BaSO_4$ and MgO have reflectance of no less than 90 % in the visible light region, their reflectance is low in the near-infrared region, and peaks of absorbance (encircled by the broken lines) were observed in the vicinities of 1,500 nm and 2,000 nm. The absorbance at these peaks originates from the moisture contained in the $BaSO_4$ and MgO. Thus, it can be understood that $BaSO_4$ and MgO have lower reflectance in the near-infrared region in comparison with the fluoropolymer white reference plate, and the white reference plate itself displays absorbance when these compounds are used.

Effect of White Reference Plates in Reflectance Measurements

Fig. 3 shows the nonwoven fabric, paper, and ceramic material used as samples. The measurement conditions were the same as those in Table 1. Relative total reflectance measurements of these samples were carried out using $BaSO_4$, MgO, and a fluoropolymer white reference plate as the white reference plates, and the spectra were compared, as shown in Fig. 4.

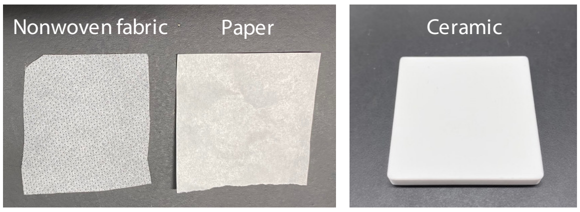

Fig. 3 Measured Nonwoven Fabric, Paper, and Ceramic

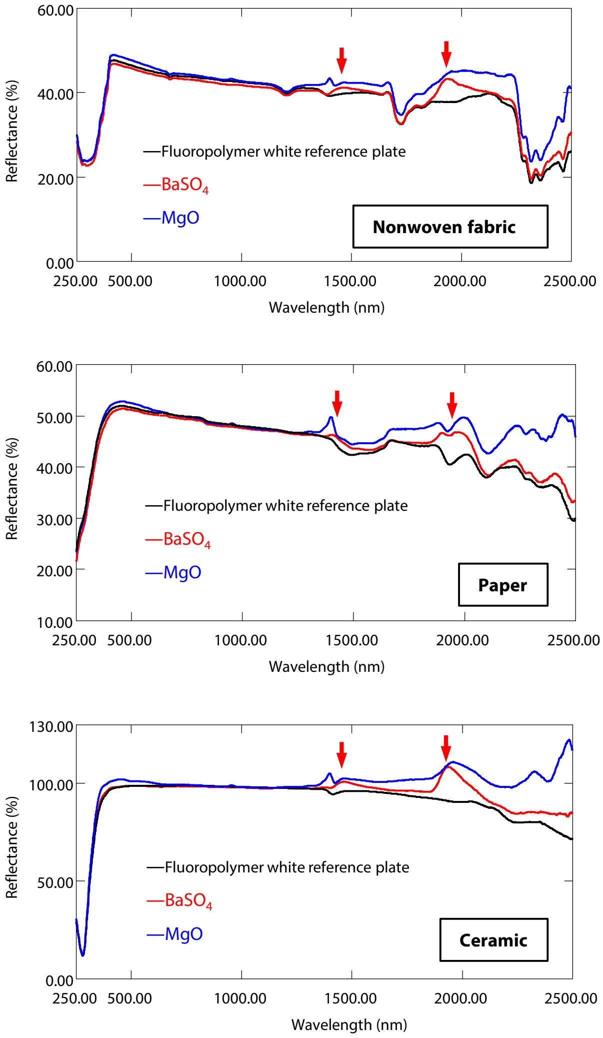

Fig. 4 Relative Total Reflectance Spectra of Samples

From Fig. 4, it can be understood that the spectra differ depending on the white reference plate used, particularly in the near-infrared region. Furthermore, the spectra when $BaSO_4$ (red line) and MgO (blue line) were used in the white reference plate were remarkably different in the vicinities of 1,500 nm and 2,000 nm, as indicated by the red arrows, due to the effect of the absorbance of moisture contained in the $BaSO_4$ and MgO of the white reference plate itself. In relative reflectance measurements, the absorbance of the white reference plate used in the baseline measurement has a direct effect on the measured value of the sample, as illustrated in Fig. 5.

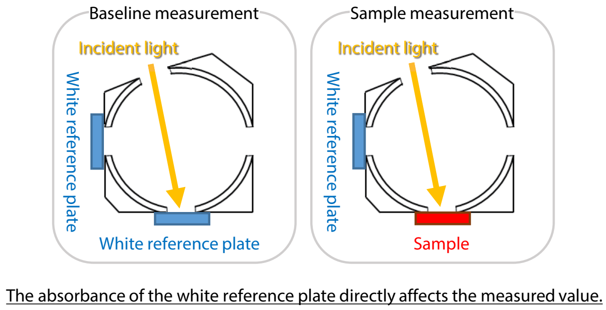

Fig. 5 Relative Total Reflectance Measurement

On the other hand, because measurements can be conducted with a fluoropolymer white reference plate without the effect of moisture described above, use of a fluoropolymer white reference plate is recommended for near-infrared measurements of diffuse samples.

Conclusion

In this article, the effect on sample measurements in case $BaSO_4$ and MgO powder reagents and a fluoropolymer white reference plate are used as the white reference plate of an integrating sphere was verified. From the measurement results, it was found that the obtained spectra differ depending on the white reference plate used, particularly in the near-infrared region. Although $BaSO_4$ and MgO are comparatively inexpensive and are widely used, it is necessary to consider the effect of the moisture contained in these substances on the measured values in the near-infrared region. On the other hand, the results confirmed that a fluoropolymer white reference plate enables measurements unaffected by moisture, even in the near-infrared region.

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