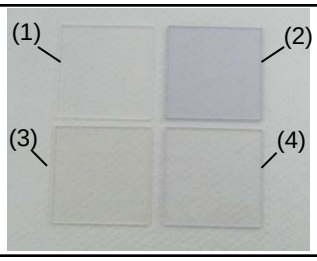
Measurement of Optical Characteristic of Plastic by UH4150 Spectrophotometer
- An example of High Throughput measurements in the UV, Visible and Near-Infrared Regions -

INTRODUCTION

Plastic is a highly transparent, light, and durable material. For the optical evaluation of an object, such as light transmittance property, color, and transparency, the transmission spectrum and reflectance spectrum are measured by a spectrophotometer. These measurements do not only provide the optical information but also the information related to optical functions such as UV and infrared ray shielding levels.
This time, the optical properties of various plastic materials were measured by using UH4150 spectrophotometer, the new model developed focusing on the photometric accuracy for solids such as optical materials. UH4150 is the spectrophotometer which inherited the optical system of U-4100 having an established reputation for its parallel beam and low polarization property that are suitable for the optical material evaluation. It is possible to change the detector and accessories depending on the analytical applications to meet various analytical requirements.
Higher throughput, compared with the conventional instrument, was achieved and the analysis with the scan speed of 1200 nm/min for the sampling interval of 1 nm is possible. For example, for the wavelength range of the analysis introduced this time, the measurement can be completed in about 2 minutes.

SAMPLE

Sample : Plastic plate (thickness of 2 mm)
(1) Polymethyl methacrylate (PMMA), (2) Polyvinyl chloride (PVC)
(3) Polyethylene terephthalate (PET), (4) Polycarbonate (PC)



INSTRUMENT CONDITIONS

Instrument : UH4150 Spectrophotometer
Measurement wavelength range: 330 to 2500 nm
Sampling interval : 1.0 nm

【UV/VIS】
Scan speed : 1200 nm/min
Slit : 8 nm

【NIR】
Scan speed : 1200 nm/min
Slit : Automatic control
PbS sensitivity : 2

ACCESSORY

ø60 standard integrating sphere (for total reflectance) (P/N : 1J1-0121)

Transmission holder (tight attachment) (P/N : 1J0-0202)

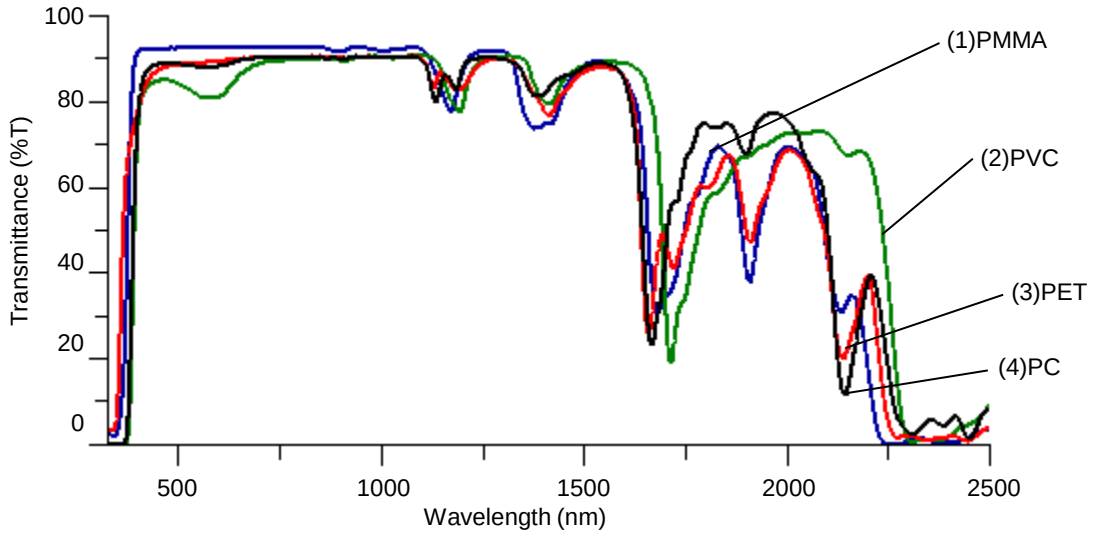


Figure 1 Transmission Spectra of Various Plastic Plates (thickness of 2 mm) by UH4150

Various plastic materials, polymethyl methacrylate (PMMA), polyvinyl chloride (PVC), polyethylene terephthalate (PET), and polycarbonate (PC) were analyzed and their transmission spectra are shown in Figure 1. It was found that the transmittance differs depending on the material.
In the visible light region, polymethyl methacrylate (PMMA) showed the highest transmittance while the difference in the spectral shapes originating from the structures is observed in the near-infrared region.

KEY WORDS

Material/Processing Material Related, Polymer Material, Plastic, Transmission Spectrum, Spectrophotometer, UH4150

Spectrophotometer (UV)

Sheet No. UV130006-01

Measurement of Optical Characteristic of Plastic by UH4150 Spectrophotometer
- An example of High Throughput measurements in the UV, Visible and Near-Infrared Regions -

SAMPLE

Sample: Plastic plate
Polymethyl methacrylate (PMMA)

INSTRUMENT CONDITIONS

Instrument : UH4150 Spectrophotometer

Measurement wavelength range : 330 to 2500 nm
Sampling interval : 1.0 nm

【UV/VIS】
Scan speed : 1200 nm/min
Slit : 8 nm

【NIR】
Scan speed : 1200 nm/min
Slit : Automatic control
PbS sensitivity : 2

ACCESSORY

ø60 integrating sphere accessory (for total reflectance) (P/N : 1J1-0121)

Transmission holder (tight attachment) (P/N : 1J0-0202)

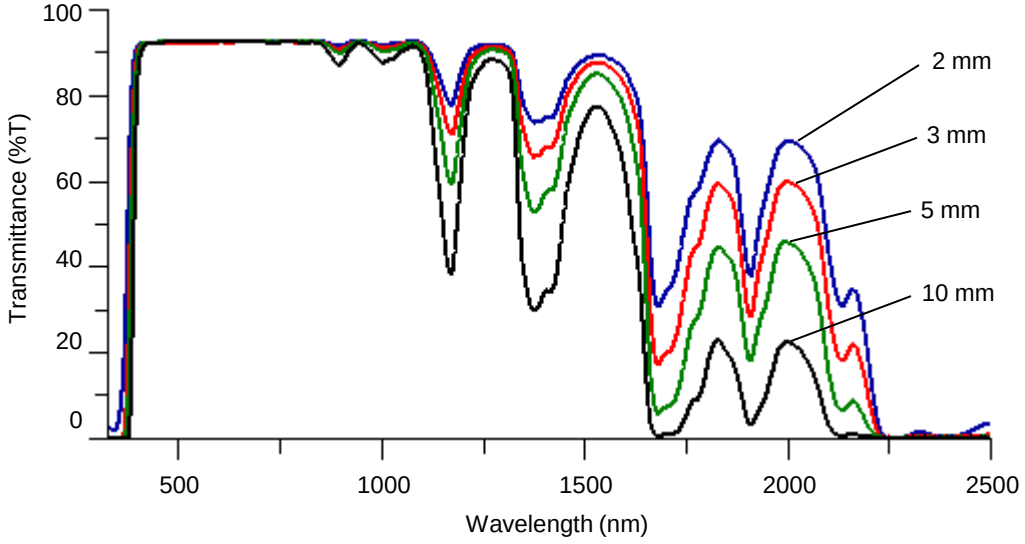


Figure 2 Transmission Spectrum of PMMA with Different Plate Thickness by UH4150

Figure 2 shows the transmission spectrum obtained by changing the plate thickness of polymethyl methacrylate (PMMA).
Polymethyl methacrylate (PMMA) has a high transmittance of about 92% in the visible light region. As the remaining about 8% reflects at the front and back of the sample, there is little absorption. Therefore, the transmittance is almost consistent regardless of the plate thickness. On the other hand, in the near-infrared region where absorption occurs, it has been confirmed that the transmittance decreases as the plate thickness increases.

KEY WORDS

Material/Processing Material Related, Polymer Material, Plastic, Transmission Spectrum, Spectrophotometer, UH4150

Spectrophotometer (UV)

Sheet No. UV130006-02

UH4150

Measurement of Optical Characteristic of Plastic by UH4150 Spectrophotometer
- A Measurement of Total Light Transmittance and Total Light Reflectance by Applying JIS K7375 -

SAMPLE

Sample : Plastic plate (thickness of 2 mm)
(1) Polymethyl methacrylate (PMMA), (2) Polyvinyl chloride (PVC),
(3) Polyethylene terephthalate (PET), (4) Polycarbonate (PC)

INSTRUNMENT CONDITIONS

Instrument : UH4150 Spectrophotometer

Measurement wavelength range : 380 to 780 nm
Sampling interval : 1.0 nm

【UV/VIS】
Scan speed : 1200 nm/min
Slit : 8 nm

ACCESSORY

ø150 standard integrating sphere (with light trap)
(P/N : 1J0-0212)

Light source mask : ø5 mm

Option package
(P/N : 1J1-0211)

Table 1 Measurement Results of Total Light Transmittance and Total Light Reflectance for Various Plastic Materials

No.	Type	Thickness (mm)	τ1(%)	τ2(%)	τ3(%)	τ4(%)	τt(%)	ρt(%)	τt + ρt(%)	YI
1	PMMA	2	100	92.3	99.4	8.2	91.7	8.2	99.9	0.2
2	PVC	2	100	82.3	99.4	8.9	81.8	8.9	90.7	-2.7
3	PET	2	100	88.8	99.4	9.9	88.2	10.0	98.2	2.5
4	PC	2	100	88.3	99.4	10.3	87.7	10.3	98.1	0.1

τ_1 : Standard incident light intensity, τ_2 : Transmitted light intensity of the sample, τ_3 : Intensity of the incident light entering the light trap, τ_4 : Reflected light intensity of the sample
Based on these measured values, τ_t : Total light transmittance (%) and ρ_t : Total light reflectance (%) were determined. Refer to JIS K7375 for the details.

$$\tau_1 = \frac{\tau_2}{2\tau_1-\tau_3-(\tau_1-\tau_3)\left(1-\frac{\rho_1}{100}\right)} \times 100$$

$$\rho_1 = \frac{\tau_4}{\tau_1-(\tau_1-\tau_3)\left(1-\frac{\tau_4}{\tau_1}\right)} \times 100$$

τ_t : Total light transmittance (%)
ρ_t : Total light reflectance (%)
τ_1 : Standard incident light intensity
τ_2 : Transmitted light intensity
τ_3 : Intensity of incident light entering the light trap
τ_4 : Reflected light intensity

Formula to Calculate Total Light Transmittance (τ_t) and Total Light Reflectance (ρ_t)

Table 1 shows measurement results of total light transmittance and total light reflectance for various plastic materials measured by the method referring to JIS K7375. By using the ø5 mm light source mask, the light beam was made into a circular shape. The transmission and reflectance spectra were measured in the visible region and the transmittance and reflectance with the D65 light source were determined*1.
As polymethyl methacrylate (PMMA) absorbs very little light in the visible light region, the sum of the total light transmittance and total light reflectance is 100.
The yellowness index (YI) determined for these samples as specified by JIS K7373 is also shown. The yellowness index describes the degree of the change in color from clear or white to yellow. The value is usually positive and a negative value indicates a blue color. In addition, the change in the yellowness after procedures such as exposure of a standard sample can be expressed as yellowing factor (⊿YI).

*1 The measurement system of JIS K7375 is different. This method is an example of the application using a spectrophotometer.

KEY WORDS
Material/Processing Material Related, Polymer Materials, Plastic, Transmission Spectrum, Spectrophotometer, UH4150

Spectrophotometer (UV)

Sheet No. UV130006-03