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Application News

No.A511

Spectrophotometric Analysis

Investigation of Ultraviolet Degradation of Plastic with Mapping Program

Plastic is degraded by ultraviolet light and heat. However, it is difficult to determine how deep degradation reaches into a material based on its external appearance. The extent of degradation inside a material can be confirmed by cutting cross sections of the material and performing mapping analysis with an infrared microscope.
We describe an analytical technique that confirms the extent of ultraviolet degradation of polypropylene plastic that is used in various everyday products, and compare the results with visual observation of ultraviolet degradation.

Polypropylene Plastic

Polypropylene (PP) is created by the polymerization of propylene and is a plastic with excellent mechanical characteristics that include tensile strength, impact strength, and compressive strength, low specific gravity, and the capacity to be easily processed. PP also has excellent heat resistance and chemical resistance, and is used in many products encountered in our daily lives, including daily commodities, home electronic components, food containers, automobile components, and medical equipment.
PP is not particularly weather resistant, and when exposed to sunlight turns white and loses its heat resistance.

Procedure for Analysis of Ultraviolet Degraded PP Plastics

First, a microtome was used to cut slices from PP plastics degraded by ultraviolet on one side, creating flat cross-sections (see Fig. 1). Next, the flat cross-sections were held horizontally and reflectance was measured, because the severe degradation made the samples too brittle for ATR measurement. The background measurement was conducted using an aluminum vapor deposition mirror.
Then the state of ultraviolet degradation was confirmed based on the spectra obtained.

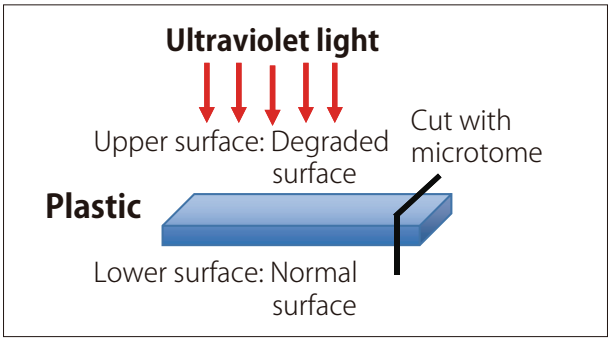

Fig. 1 Flat Cross-Sections from Degraded PP Plastic

Table 1 FTIR Spectroscopy Conditions

Instrument	: IRTracer-100 AIM-9000
Resolution	: 8 cm^{-1}
Accumulation	: 30
Apodization	: Happ-Genzel
Detector	: MCT
Aperture	: 40 µm × 40 µm
Mapping	: Area
Step	: 40 µm

Analysis

Analysis and aperture conditions are shown in Table 1. When setting aperture, the site to be measured is displayed as shown in Fig. 2. Forty-nine points located in a 280 × 280 µm grid pattern shown in Fig. 2 were measured using the analytical conditions shown in Table 1.

Analytical Results

Results show the C=O derived peak around 1750 cm^{-1} and the O-H derived peak around 3400 cm^{-1} increase in size with increasing degradation. Fig. 3 shows a map of corrected peak heights around 1750 cm^{-1} and Fig. 4 shows spectra of normal and degraded parts of the sample.

Fig. 3 shows that degradation is more advanced on the left side of the measurement area than on the inner right side. This mapping shows that degradation reaches approximately 200 µm into the material.

Conclusion

Degradation of plastics caused by ultraviolet light and heat reaches below the surface. We cut cross-sections of plastic and visualized the depth of degradation using infrared spectrophotometry.

The AIM-9000 infrared microscope and AIMsolution software allowed us to easily view the entire measurement site, and visually observing the sample simultaneous to analysis also enabled us to relate analytical results with our view of the measurement site.

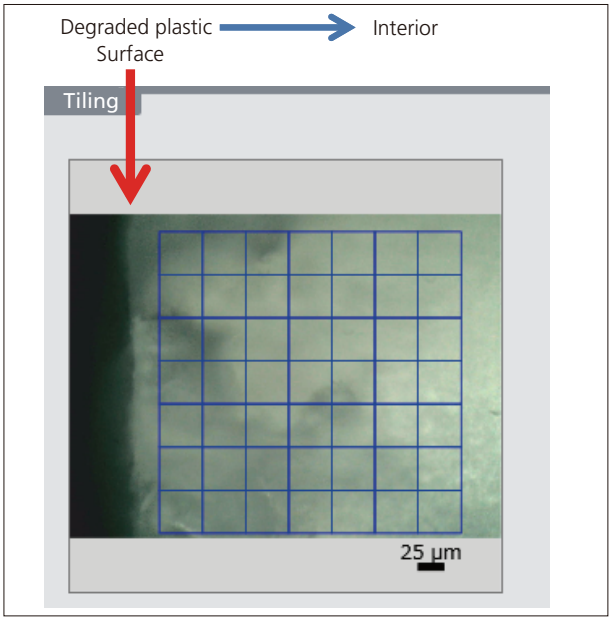

Fig. 2 Image Displayed After Setting Aperture

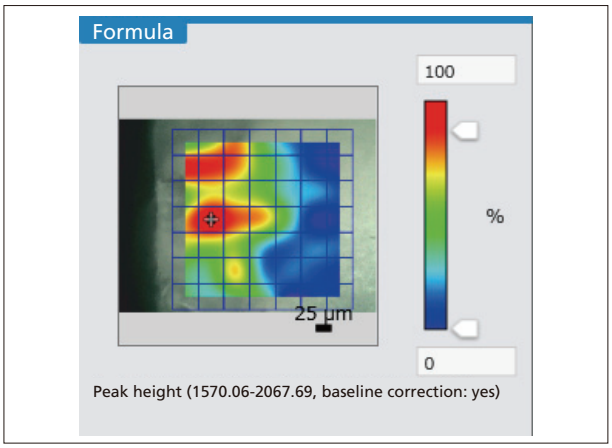

Fig. 3 Mapping Image Obtained at Corrected Peak Height of Around 1750 cm^{-1}

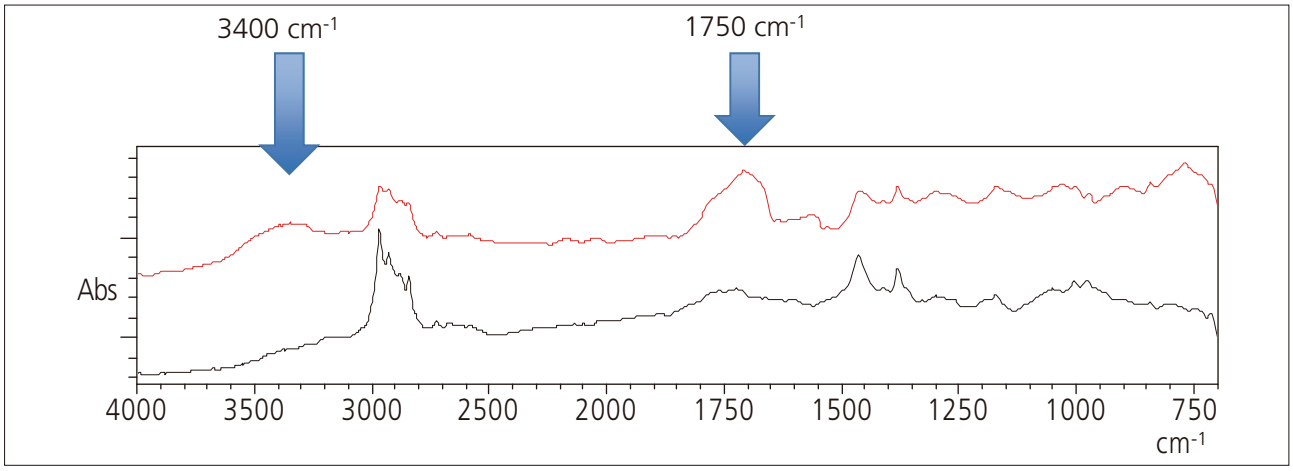

Fig. 4 Infrared Spectra of Normal (Black) and Degraded (Red) Areas

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