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Application News

IRSpirit™ Fourier Transform Infrared Spectrophotometer

Deterioration Analysis of Automobile Headlight Cover by Plastic Analyzer

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User Benefits

- Deterioration analysis and contaminant analysis of plastics can be conducted easily, even by persons who are relatively unfamiliar with FTIR measurement.
- Deteriorated plastics can be analyzed smoothly by using Shimadzu original UV-damaged/thermal-damaged plastics library.
- Simple qualitative analysis is possible, even when it is difficult to obtain a flat specimen surface, by cutting out the area of interest.

■ Introduction

Many plastic materials are used in automobile parts from the viewpoints of weight reduction and processability, but with long use, these parts may become yellow and brittle due to the effects of heat and ultraviolet (UV) radiation in outdoor environments. The libraries included in Shimadzu Plastic Analyzer contain a large number of infrared spectra of plastics that have been damaged by UV radiation or heating, and are effective in deterioration analyses of automotive parts that are difficult to analyze with commercially-available databases.

This article introduces an example of an analysis of an automobile headlight cover using Plastic Analyzer.

■ Plastic Analyzer

Plastic Analyzer is a system comprising an IRSpirit Fourier transform infrared spectrophotometer, a QATR™-S single-reflection ATR measurement accessory, and the Plastic Analyzer Method Package, and is an effective product for contaminant analysis and deterioration analysis (Fig. 1).

The Method Package is a macro program that includes Shimadzu original UV-damaged plastics library, thermal-damaged plastics library, and the optimum measurement parameters. The attached analysis handbook provides the structural formulas, infrared spectra, and distinctive peak vibration modes for 14 types of plastics.

Fourier Transform Infrared Spectrophotometer Plastics Analysis System
Plastic Analyzer

Composition:

- IRSpirit Fourier transform infrared spectrophotometer
- QATR-S single-reflection ATR measurement accessory
- Plastic Analyzer Method Package
  1. UV-damaged plastics library
  2. Thermal-damaged plastics library
  3. Dedicated program/parameters for IR Pilot™

Fig. 1 Plastic Analyzer

■ UV-Damaged Plastics Library

This is an original Shimadzu library containing the infrared spectra of UV-damaged plastics for 14 types of plastics which were exposed to UV radiation for up to a maximum of 550 hours (equivalent to UV exposure for approximately 10 years) using a super accelerated weathering chamber manufactured by Iwasaki Electric Co., Ltd. In addition to contaminant analysis and deterioration analysis, it is also effective in analyses of microplastics, which have attracted attention as an environmental problem in recent years.

■ Thermal-Damaged Plastics Library

This original Shimadzu library was prepared with the cooperation of the Hamamatsu Technical Support Center of the Industrial Research Institute of Shizuoka Prefecture, and contains infrared spectra for 13 types of plastics that were thermally-damaged by heating to temperatures from 200 ˚C to 400 ˚C, together with undamaged samples measured without heating.

■ Measurement Specimen

An automotive headlight cover was analyzed. Fig. 2 shows a photograph of the measurement specimen. In Fig. 2, discoloration or other deterioration of the specimen appearance cannot be seen at the position shown by the blue circle (this position is called the “transparent part”), whereas discoloration due to outdoor exposure can be confirmed at the position indicated by the yellow circle (“yellowed part”), which is near the center of the headlight cover. After cutting out the transparent part by the knife at the edge of the headlight cover and the yellowed part at the center, the surfaces that had been exposed outdoors were analyzed by the ATR method.

Fig. 2 Measurement Specimen
(Yellow Circle: Yellowed Part, Blue Circle: Transparent Part)

The operations in this analysis were carried out using IR Pilot, a dedicated macro program included in the Plastic Analyzer Method Package. When this dedicated program is used, there is no need to set the measurement wavelength range, resolution, accumulation, or other analysis parameters that must be set before conventional measurements. For details, please refer to Application News No. A647.

■ Measurement Results

Fig. 3 shows the overlay of the infrared spectra of the transparent part and the yellowed part obtained by Plastic Analyzer.

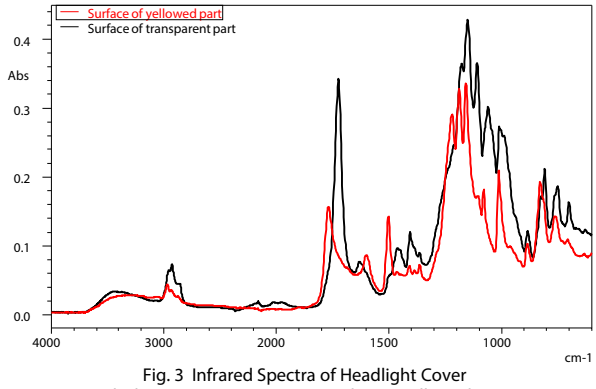

Fig. 3 Infrared Spectra of Headlight Cover
(Black Line: Transparent Part, Red Line: Yellowed Part)

Comparing the transparent part and the yellowed part, the transparent part appears to be the spectral shape of the yellowed part + some other substance. First, therefore, a search of the yellowed part was conducted. Fig. 4 shows the obtained search result.

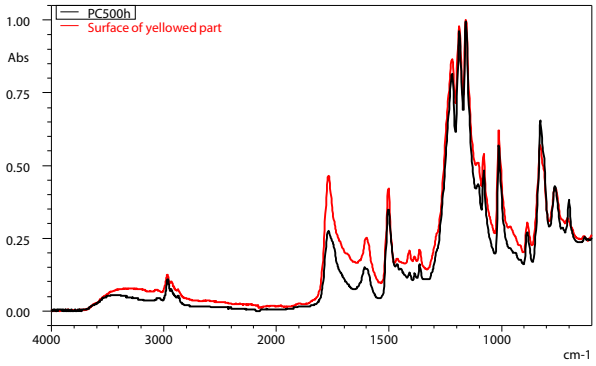

Fig. 4 Search Result of Yellowed Part

From Fig. 4, it was found that the yellowed part is deteriorated polycarbonate (PC).

Next, in order to investigate other components of the transparent part, the difference spectrum of the transparent part and the yellowed part was calculated, and a search of the obtained difference spectrum was conducted. Fig. 5 shows the obtained difference spectrum, and Fig. 6 shows the search result.

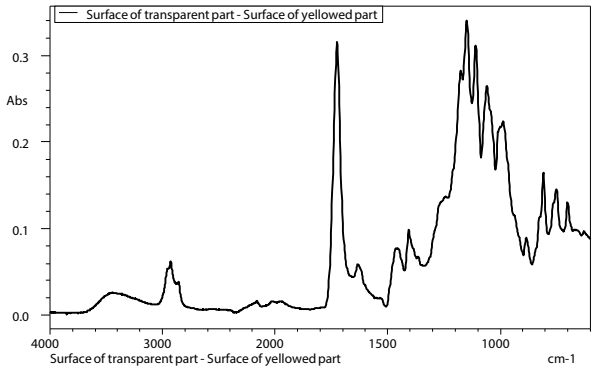

Fig. 5 Difference Spectrum of Transparent Part - Yellowed Part

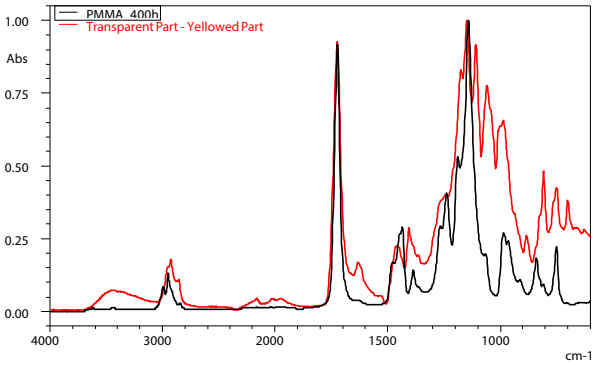

Fig. 6 Search Result of Transparent Part - Yellowed Part

From Fig. 6, a hit was obtained for polymethylmethacrylate (PMMA), which is registered in the UV-damaged plastics library. PC is frequently used in headlight covers because it has high mechanical strength and is resistant to fragmentation when cracked, but conversely, it is known to have poor resistance to UV. Since PMMA is essentially unaffected by UV, it is assumed that this PMMA was used as a coating material to prevent UV damage of the PC headlight cover.

Here, the weak absorption at around 3400 cm^{-1} seen in common in both the transparent part and the yellowed part is thought to be absorption due to O-H stretching vibration caused by oxidative degradation by sunlight (i.e., UV).

■ Conclusion

The followings can be inferred from the results of the analysis introduced in this article.

1. The main component of both the transparent part and the yellowed part is PC.
2. Because O-H stretching vibration was confirmed from the infrared spectrum of the transparent part, deterioration had also proceeded in that part, although not to the point of discoloration.
3. Deteriorated PMMA was detected from the surface of the transparent part, and seems to have originated from a coating material used to prevent deterioration of the PC.
4. PMMA was not detected from the surface of the yellowed part. Because deterioration of the yellowed part had progressed further than in the transparent part, it is thought that the coating had peeled off in the yellowed part.

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