

# Application News

## No. A501

### Spectrophotometric Analysis

## Analysis of Thermally Degraded Plastics Using Thermally Degraded Plastics Library

-Applications to Contaminant Analysis-

### ■ Introduction

In daily life, we encounter a variety of natural products and manufactured goods. In fields such as food products, pharmaceuticals, and machinery, effort is put into quality assurance, striving to prevent the incorporation of contaminants. However, the incorporation of contaminants does inadvertently occur due to unforeseen factors and problems.

While there are many types of contaminants, the plastic parts used in production line, specific environments, and the vicinity become brittle due to aging and thermal degradation, making their incorporation in part a possibility.

FTIR is optimal for the analysis of such plastic contaminants. However, the infrared spectrum of degraded plastic differs from the spectral pattern before degradation. Accordingly, in searches using commercially available plastics libraries, even if a search result has top ranking, it can inadvertently consist of the spectral pattern for a different substance, making identification and qualification difficult.

In this article, we introduce an example of the changes to the infrared spectrum of a plastic degraded by heat, and a sample search using a library containing data created by changing the heating temperature and time beforehand.

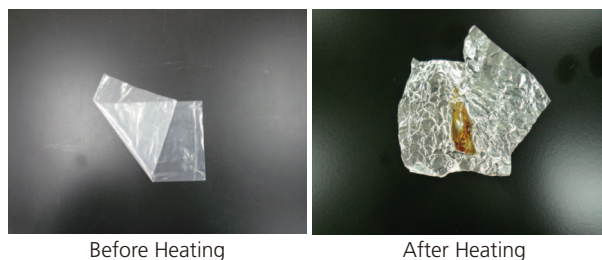
### ■ Changes to the Spectrum of a Polyethylene Film Due to Thermal Degradation

A polyethylene film was wrapped in aluminum foil, and then heated on a hot plate. As it was heated in air, the polyethylene film was subject to oxidative degradation.

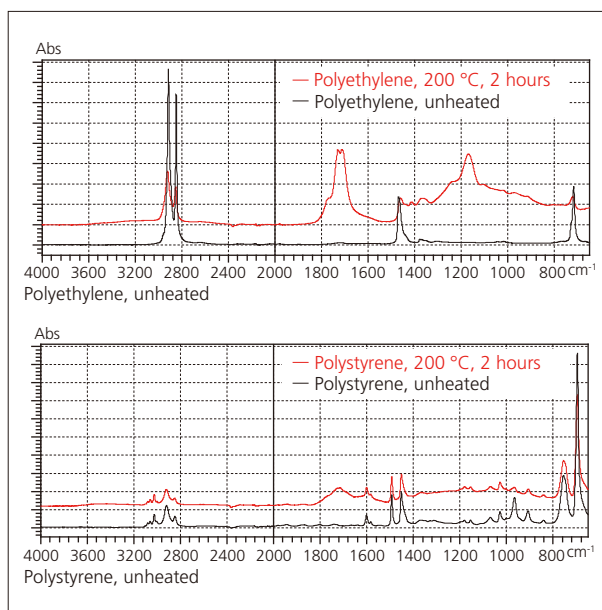
Fig. 1 is a photograph of the polyethylene film before heating, and then after heating at 200 °C for two hours. Before heating, it was transparent. After heating, however, it evidently turned brown.

Fig. 2 (top) shows the respective infrared spectra. The measurements were performed using the single bounce ATR method. Polyethylene has a repeating  $-(CH_2)_n$ -structure, so before heating, peaks due solely to this structure are visible near 3000  $cm^{-1}$ , 1400  $cm^{-1}$ , and 700  $cm^{-1}$ .

As a result of heating, in addition to the original peaks, there are peaks in the 1700  $cm^{-1}$  to 1750  $cm^{-1}$  range due to  $-C=O$ , and peaks in the 1100  $cm^{-1}$  to 1200  $cm^{-1}$  range due to  $-C-O-$ . These are likely due to oxidative degradation. Fig. 2 (bottom) shows the spectra for polystyrene film before and after an identical heat treatment. Identical changes are visible here as well.



**Fig. 1 Polyethylene Film Before Heating, and After Heating at 200 °C for 2 Hours**



**Fig. 2 Top: Infrared Spectra of Polyethylene Film Before Heating (Black) and After Heating at 200 °C for 2 Hours (Red). Bottom: Polystyrene Film Before Heating (Black) and After Heating at 200 °C for 2 Hours (Red)**

Analysis of a Contaminant on a Plated Part

A semi-transparent light brown contaminant was visible on a plated product. This area was measured, and the spectrum in Fig. 3 was obtained. A search of the spectrum was performed using a standard library directly, but no equivalent spectra were found. As shown in Fig. 2, a portion is similar to heated plastic, so it is presumed to be plastic that had been changed by heating.

Searches Using Thermally Degraded Plastics Library

As in Figs. 2 and 3, with heating, the infrared spectral pattern is changed due to oxidation. Typical search libraries contain the infrared spectra for plastic samples measured in an unheated state. As a result, if a search is performed directly, there is a risk that the results obtained will be different than for plastic samples after heating. This article introduces the Thermally Degraded Plastics Library, a proprietary library compiled by Shimadzu. It consists of spectra obtained by measuring samples at the Industrial Research Institute of Shizuoka Prefecture's Hamamatsu Technical Support Center. The library contains 13 plastics, both unheated and thermally degraded at temperatures from 200 °C to 400 °C. Fig. 4 shows the results of a search utilizing these. It is evident that the heated plastics have top ranking. In addition, this library contains infrared spectra changed by heating temperature and heating time, which will be useful for estimating the thermal history of a plastic. Note that this library is not intended for searches of heating time and heating temperature, but is considered for investigating the thermal history of a sample.

Conclusion

It is evident that qualitative analysis of plastics that have undergone thermal changes can easily be performed by searching the Thermally Degraded Plastics Library. This library will prove useful in contaminant analysis.

Table 1 FTIR Analysis Conditions

Instrument	: IRTracer-100
	MIRacle10
Resolution	: 4.0 cm <sup>-1</sup>
Accumulation	: 100
Apodization	: Happ-Genzel
Detector	: DLATGS

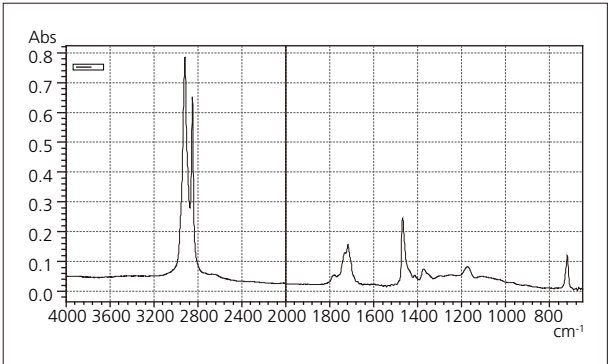
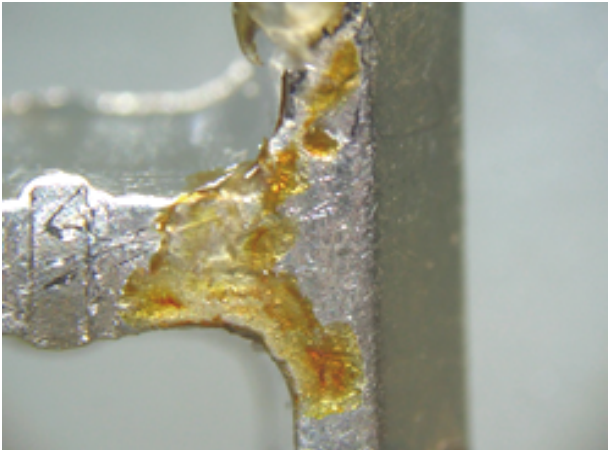


Fig. 3 Photograph of a Contaminant on a Plated Part (Top); Measured Infrared Spectrum (Bottom)

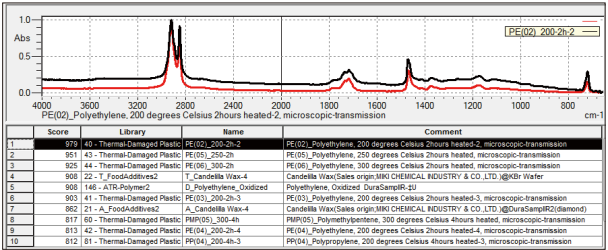


Fig. 4 Search Results Using the Thermally Degraded Plastics Library



Shimadzu Corporation  
www.shimadzu.com/an/

For Research Use Only. Not for use in diagnostic procedures.  
This publication may contain references to products that are not available in your country. Please contact us to check the availability of these products in your country.  
The content of this publication shall not be reproduced, altered or sold for any commercial purpose without the written approval of Shimadzu. Company names, product/service names and logos used in this publication are trademarks and trade names of Shimadzu Corporation or its affiliates, whether or not they are used with trademark symbol "TM" or "®". Third-party trademarks and trade names may be used in this publication to refer to either the entities or their products/services. Shimadzu disclaims any proprietary interest in trademarks and trade names other than its own.  
The information contained herein is provided to you "as is" without warranty of any kind including without limitation warranties as to its accuracy or completeness. Shimadzu does not assume any responsibility or liability for any damage, whether direct or indirect, relating to the use of this publication. This publication is based upon the information available to Shimadzu on or before the date of publication, and subject to change without notice.

## Related Products

Some products may be updated to newer models.



> IRTracer-100  
Fourier Transform Infrared  
Spectrophotometer

## Related Solutions

> Price Inquiry

> Product Inquiry

> Technical Service /  
Support Inquiry

> Other Inquiry