Complementary Use of Raman and FT-IR Imaging for the Analysis of Multi-Layer Polymer Composites

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Overview

Polymer: To compare and contrast the benefits of FTIR and Raman microspectroscopy

Methods:

FTIR and dispersive Raman microscopes were used to assess multi-layer polymer composites. Raman and FTIR optical microscopy was used to study the benefits and shortcomings of each technique.

Results:

An important advantage of FTIR microscopy is that it specifically highlights functional groups along with a few distinct polymer backbone features.

Conclusions:

The complementary nature of these two forms of vibrational spectroscopy can be exploited to analyze the microstructure of multi-layer polymer composites because they support each other by addressing the shortcomings of the other technique and providing complementary information.

Introduction

A variety of different industries utilize multi-layer polymer composites specifically engineered for particular performance characteristics. Confirming the composition and identifying the materials is typically conducted both for the capability that manufacturer possesses to create such materials and to verify the integrity of the final product. Raman and FTIR micro-spectroscopy are both utilized as a technique for the analysis of polymer composites. They can be used to re-identify unknown materials as well as providing information on molecular structure and chemical environment.

FTIR micro-spectroscopy offers a non-destructive and non-ionizing technique for imaging and provides a convenient way to evaluate the distribution of components in a multi-layers polymer composite. Each chemical component displays its characteristic fingerprint spectra and can be utilized to identify the component in the sample. FTIR micro-spectroscopy, however, should not be used as the method of choice rather than Raman microspectroscopy. FTIR is not capable of identifying unknown substances, and it also suffers from the lack of a true molecular selectivity because it identifies every functional group of similar wavelengths.

Raman micro-spectroscopy is advantageous for identifying unknowns and for obtaining structural information from a polymer layer. However, there are a few limitations to this technique. One disadvantage of Raman spectroscopy is the influence of sample scattering media that can affect the quality of the recorded spectrum. Also, Raman micro-spectroscopy is less sensitive to detect components with low concentrations in a multi-layer polymer composite. FTIR and dispersive Raman microscopy offers additional advantages to the user for analysis of layers of polymer composites.

Methods

A Thermo Scientific™ DXR™xi Raman imaging microscope was used to collect the micro-spectroscopic data. The Thermo Scientific™ iN10™ FT-IR microscope was used to collect the FTIR spectra.

Results

Sample Preparation

The cross-sectioned samples for Raman analyses were prepared using the Thermo Scientific™ Polymer slicing tool for DXR Raman microscopes. The sample used for FTIR imaging analyses was cut using a Bonray 3100 microtome. Cross-sectioned slices of the layered composites were used for the ATR analyses.

Results

Figure 1 shows the results of Raman imaging of a new film that was used in Figure 2. The Raman imaging was conducted using a 785 nm laser at 30 mW as the excitation source. The laser line was focused on the center of the film. The resolution for the micro-spectroscopic data is 1 m and the image pixel size was 0.5 µm.

Figure 7 shows the FTIR mapping of a layered polymer composite. The image area is 33 µm and the image pixel size was 0.5 µm. The spectra were selected using an absorbance peak at 1738 cm⁻¹ for the polymer layer #1. The MCR profile did not resolve the other polymer layers in the sample. The MCR profile did not resolve the other polymer layers in the sample.

Conclusion

Weather the film is a quality assurance, batch analysis, or reverse engineering of hybrid polymer samples, Raman and FTIR microspectroscopy offers distinct advantages in terms of their analytical applications. Imaging and mapping images provide visualizations of the polymer components or variations in molecular structure.

An important advantage of FTIR microspectroscopy is that it specifically highlights functional groups along with a few distinct polymer backbone features. However, the FTIR spectra show diagnostic peaks for all the polymeric materials that are present in the sample. The FTIR spectra of the polymer layers show diagnostic characteristic bands for each polymer in the layer.

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The complementary nature of these two forms of vibrational spectroscopy can be exploited to analyze the microstructure of multi-layer polymer composites because they support each other by addressing the shortcomings of the other technique and providing complementary information.