Infrared Microscopy for the Analysis of Polymer Laminates in Beverage Packaging

Laminates are combinations of polymers that combine the benefits and properties of the various polymers used in the laminate to create a better material. Polymer laminates have a multitude of uses including packaging for food and other products. Laminates act as moisture and/or oxygen barriers and as such are commonly used to protect foods and chemicals. Analysis of laminates is often required for quality control and to determine laminate adhesion problems.

Introduction

Modern polymers are seldom used as pure materials, more often mixtures of different polymers are combined to give the desired physical characteristics. For example, the rigidity of polystyrene is often combined with an elastic polymer to produce stiff yet shock resistant materials. Polymeric laminates are important in the microelectronics, medical, food packaging, and chemical industries. Since laminates act as moisture and/or oxygen barriers, they are commonly used to protect foods and chemicals.

JASCO FT-IR Spectrometers

There are many methods that can be used to generate these mixtures but one of the most common is to simply assemble the polymers into layers and create a laminate. The most widely used structural spectroscopic measurement for laminates is Fourier Transform infrared (FTIR). FTIR spectroscopy is a non-destructive technique that allows chemical identification of the component materials in the laminate.

Infrared spectroscopy provides the ability to study the interactions of the vibrational and rotational energies of atoms or groups of atoms within molecules and is a powerful qualitative and quantitative tool. Infrared spectra reflect vibrational motions that produce a change in the permanent dipole moment of the molecule. There is a large amount of information that can be gained by using infrared spectroscopy for the analysis of polymers. Minor changes to the molecular structure usually result in a spectrum that is clearly distinguishable from the spectrum of the original compound. Thus, the infrared spectra can be used to identify the presence of a specific chemical compound or mixture of compounds.

Experimental

Several different polymer materials were selected for analysis including a prepared juice bottle and a plastic food container. Laminate samples of controlled thickness were sectioned with a razor blade and the cross section examined using the FT-IR microscope. Microscope apertures ranging from 15 x 15 microns to as large as 50 x 50 microns were used to define sample areas for analysis.

Analysis was performed using a JASCO FT/IR-620 and IRT-30 FT-IR microscope with a ceramic source, KBr beamsplitter, and MCT detector. The resolution was 4 cm^{-1}, with 64 co-added scans for the single-beam background and sample spectra. The spectral range was from 4000-700 cm^{-1}.

Figure 1. Juice bottle laminate examined using the FTIR microscope, visually, you can identify at least 4 layers in this image.
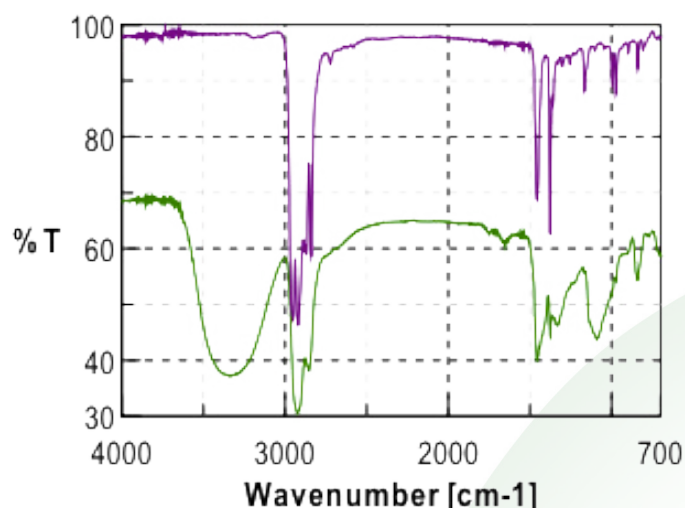

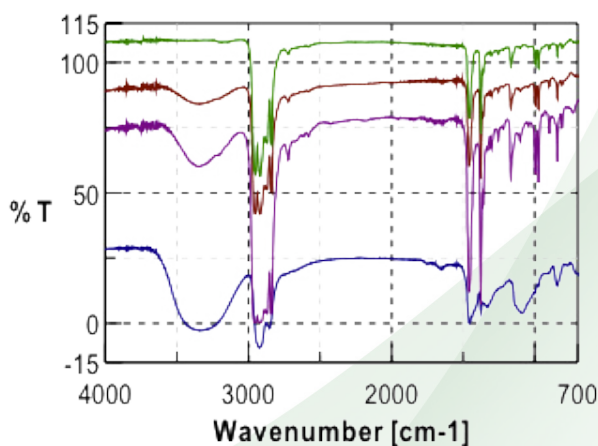**Figure 2.** Infrared spectra of laminate polymers. Top: polypropylene Bottom: polyvinyl alcohol.

Figure 3. Juice bottle laminate layers demonstrating the transition of the polymer layers from polypropylene to polyvinyl alcohol.

JASCO INC.
28600 Mary's Court, Easton, MD 21601 USA
Tel: (800) 333-5272, Fax: (410) 822-7526
Application Library: http://www.jascoinc.com/applications

Initial investigation of the polymer laminate found that the primary components of the laminate were polypropylene (PP) and polyvinyl alcohol (PVOH). Further study and careful examination of the laminate polymer immediately adjacent to the PVOH layer revealed a gradient in the ratio of the polypropylene (PP) and polyvinyl alcohol (PVOH) polymers.

Conclusions

Laminate appears to comprise 6 layers. PP (polypropylene) and a highly hydrolyzed form of the PVOH (polyvinyl alcohol) were identified as the primary components based on the comparison of the infrared spectra to spectral libraries. There appear to be two slightly different PP types; PP1 and PP2 are probably m.wt. variants or PP1 may simply contain a small amount of an additive to provide the change in optical density. Additionally, it was determined that there was a mixing of the polymers at the interfaces. Infrared spectroscopy was not only able to identify the layers but also to give information on the polymer mixing occurring at the interface. This valuable information will allow a more accurate determination of the physical properties of the polymer and how it will handle stresses at the interface between the laminate layers.