Application Note AN M109

Identification of O-Rings with FT-IR

Introduction

The use of wrong O-rings poses a high risk of severe accidents and expensive damages as it might result in failure of machines and even complete industrial production facilities. O-rings are made from a very broad range of different compositions which can differ dramatically in terms of chemical and physical properties. An O-ring made from the fluorinated Viton® will have excellent chemical stability to most chemicals and can withstand even aggressive substances like bromine but when it is brought into contact with acetone it will readily dissolve. Since it is impossible to discern different kinds of O-ring materials just by visual inspection a fast and reliable method for the chemical analysis of all kinds of O-ring materials is needed.

FT-IR spectroscopy is a versatile and nondestructive method for the identification of O-ring materials. A spectrum can be measured within seconds applying the Attenuated-Total-Reflection (ATR) technique where the sample just has to be pressed onto the ATR-crystal that serves as sample interface. The ALPHA II FT-IR spectrometer in combination with the Eco Germanium-ATR unit is the ideal tool for the identification of O-rings. The evaluation of the spectra is performed automatically by means of the dedicated Bruker O-ring library. This library contains 280 spectra of O-rings made from various common rubber materials including ACM, AEM, AU/EU, BR, CR, EPM, EPDM, FEPM, FKM, FFKM, FVMQ, HNBR, NBR, and VMQ.

Keywords	Instrumentation and Software
FT-IR	ALPHA II FT-IR Spectrometer
O-Rings	OPUS Spectroscopy Software
Spectral Libraries	ECO Germanium ATR
Rubbers and Elastomeres	

Method and Instrumentation

Modern routine IR spectroscopy is mainly performed by applying the ATR (Attenuated Total Reflection) technique, as this is much more comfortable to use than the conventional transmission mode. Hereby the IR radiation penetrates slightly (a few microns) into the sample surface. The IR detector of the FT-IR spectrometer measures the wavelength dependent absorbance resulting from the sample.

High refractive index samples like black rubbers need an ATR-crystal with a particularly high refractive index since the ATR-effect will only take place when the refractive index of the crystal exceeds the one from the sample. An ideal crystal material for such samples is germanium which combines a high refractive index of 4.01 with a quite good mechanical and chemical robustness. In addition germanium-crystals have a relatively low penetration depth which is ideal for highly absorbing samples such as rubbers with a high black carbon content. An ALPHA II FT-IR spectrometer equipped with an Eco germanium ATR unit is shown in figure 1.

Figure 1: ALPHA II FT-IR spectrometer with Eco germanium ATR sampling module.

Application example: Identification of different O-ring materials

In our examples we are measuring three different O-rings of varying sizes that were taken from a workshop collection without labeling. Our first example shows the measurement of a 7 mm O-ring made from an unknown material. The result of the library search is shown in figure 2, with the sample spectrum shown in red and the library spectrum of the first hit shown in blue. The baseline drift of both spectra results from the very high black carbon content of the sample. With a very good hit-quality of 924 (max. 1000) the sample is being identified as a Nitrile Butadiene Rubber (NBR). For each of the library entries information about the name and type of the rubber is listed as well as the hardness, color, manufacturer and other information.

The library search of the spectrum from the second sample provides an excellent match with the library spectra, too. Figure 3 shows the sample spectrum of the unknown O-ring (blue) together with the spectrum of the best library hit (red). The sample was identified with an excellent hit-quality of 990 to be a silicone rubber. Additionally we get the information about the product name (S70) and the manufacturer (Spec Seals) of the library sample.

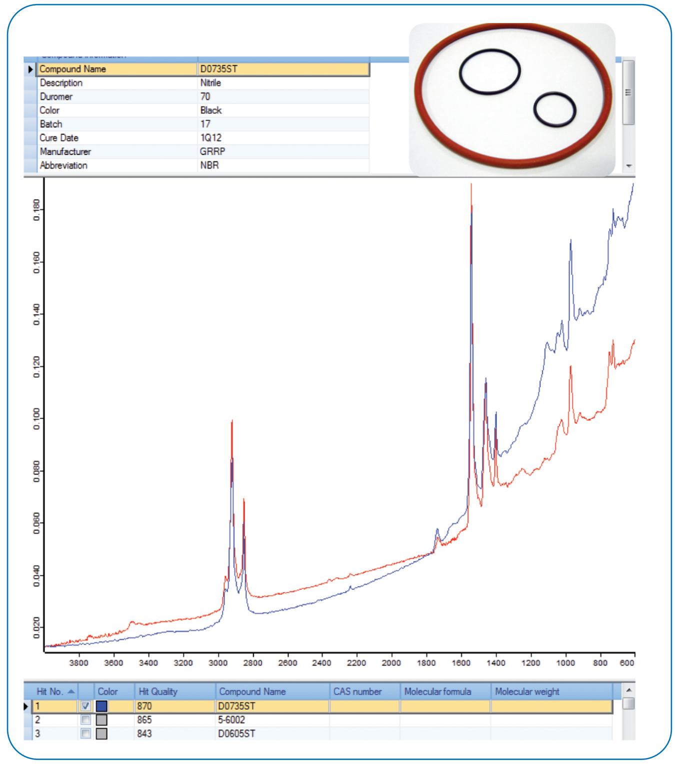

Figure 2: Search result window with sample- (red) and library-spectrum (blue). The zoom spectral Range shows the weak but characteristic nitrile band at 2240 cm^{-1}. Inset: O-rings used as test samples, diamenter of the outer ring ca. 7 cm.

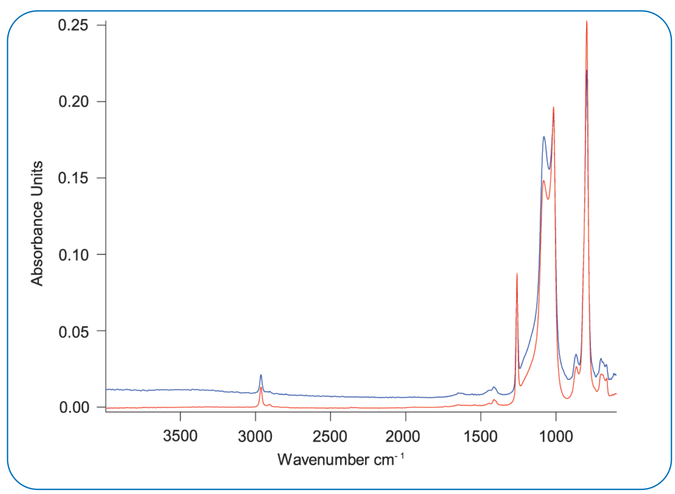

Figure 3: Sample (red) and library (blue) spectra of the 2nd sample.

The last sample is identified with a very good hit-quality of 994 to be a fluorocarbon (FKM) both sample (magenta) and library spectrum (black) are shown in figure 4; again the similarity is clearly visible. The search result shows both product name (514AD) and the manufacturer ("Minnesota") of the library sample.

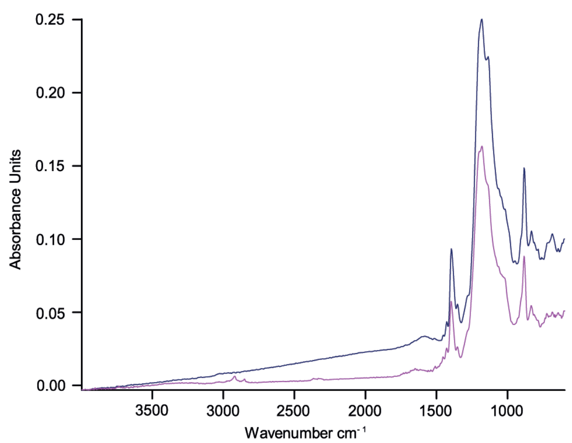

Figure 4: Sample (magenta) and library (black) spectra of the 3rd sample.

Summary

The dedicated O-ring library from Bruker in combination with the ALPHA II and the ECO germanium-ATR is the ideal tool for the identification and quality control of O-rings and related rubbers. The analysis of an O-ring is nondestructive. Both measurement and evaluation can be performed even by inexperienced personnel within a few seconds.

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