Epoxy primer thickness on aluminum measured with the handheld Agilent 4100 ExoScan FTIR

Reliable analysis, even on thin coatings

Application Note

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Abstract

The handheld Agilent 4100 ExoScan FTIR can be used to effectively measure epoxy primer thickness on aluminum. The calibration technique facilitates accurate predictions. Sensitive enough to detect even small discrepancies in thickness, the system is ideal for use in aircraft applications.

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Introduction

Determination of primer thickness is key to the quality control of many painting processes. Ultrasonic and Eddy Current probes can be used to measure coating thicknesses; however, they often lack the resolution required for thin primer coats.

The Agilent 4100 ExoScan FTIR is a handheld infrared (IR) spectrometer. It enables easy measurement of both chemical composition and thickness of organic and oxide layers on metallic surfaces. The absorbance of IR spectral bands is directly related to the concentration of a chemical substance, and the pathlength of the light through that substance. The 4100 ExoScan external reflectance sample interface used in these studies transmits the light completed through thin coatings and collects the reflected light. Since the pathlength is defined by the coating thickness, the IR absorbance is directly proportional to the coating thickness. Additionally, since IR absorbance bands are specific to chemical functionality, the method can be designed to look at bands solely due to the epoxy resin in the primer, making it unaffected by additives and fillers. Unlike other lab based IR spectrometers, the handheld 4100 ExoScan enables non destructive analysis of large parts.

This study demonstrates the use of the 4100 ExoScan FTIR for determining epoxy based primer thickness on aluminum panels. A series of calibration standards were measured by the 4100 ExoScan; their IR absorbance was correlated to the thickness as measured by destructive physical testing methods. A second set of 'unknown' samples were tested, showing that the thickness could be accurately measured.

Samples and experiment

All samples consisted of an aircraft grade epoxy primer coated on aluminum panels. In the calibration set, the primer thicknesses were 0.06, 0.09, 0.17, 0.30 and 0.39 mils (1.5, 2.3, 4.3, 7.6 and 9.9 µm). All samples were measured using a 4100 ExoScan FTIR with an external reflectance sample interface; a picture of the 4100 ExoScan in use is shown in Figure 1. The measurements consisted of 32 co-added scans at 8 cm^{-1} resolution, yielding a sample measurement time of about 8 seconds. Backgrounds were measured off a bare aluminum sample for each sample, also taking 8 seconds each.

Figure 1. The handheld Agilent 4100 ExoScan FTIR with the external reflectance sample interface being used for quality inspection of an aircraft coating

Results

Spectra collected from the calibration samples are shown in Figure 2. These spectra, shown from 2000 to 650 cm^{-1} display many bands, which are due to the epoxy coating.

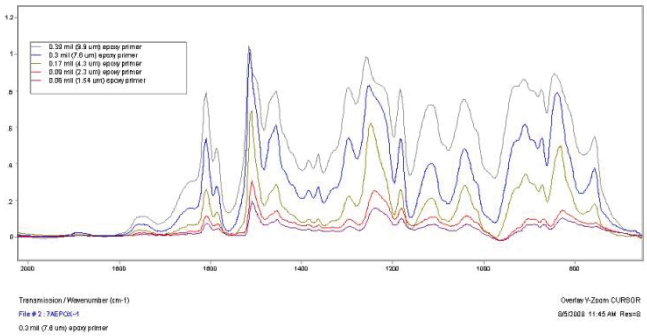

Figure 2. IR spectra collected with the Agilent 4100 ExoScan FTIR using the external reflectance sample interface of epoxy primer on aluminum sheet ranging in thickness from 0.06 mils (1.54 microns) to 0.39 mils (9.9 microns)

For the range of thickness measured, several bands could be used to determine the primer thickness. In this calibration, the band centered at 1610 cm^{-1} was used. This band had an absorbance of approximately 0.07 absorbance units for the thinnest sample and 0.7 absorbance units for the thickest sample. This falls within the linear range of IR absorbance (typically 0.05 to 1 absorbance units). It should be noted that both stronger bands (that is, 1510 cm^{-1}) and weaker bands (that is, 1285 cm^{-1}) exist, which could be used for thicker or thinner calibration ranges respectively. Figure 3 shows the calibration curve for epoxy thickness as measured by the band area for the epoxy band at 1610 cm^{-1}. The calibration shows an excellent linear fit between the IR data and the actual epoxy thickness.

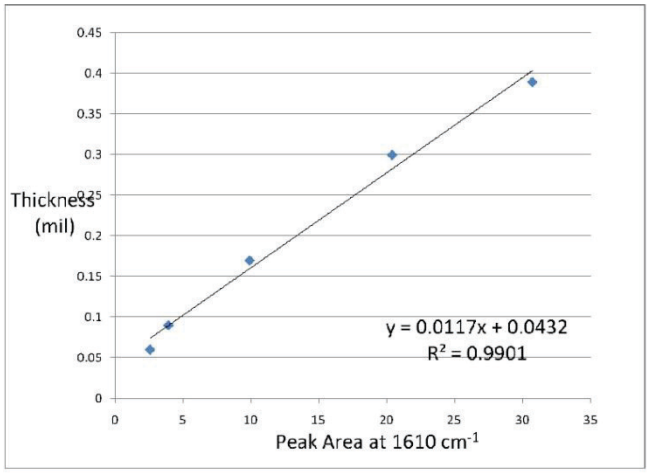

Figure 3. Calibration plot of epoxy primer thickness as measured with the Agilent 4100 ExoScan FTIR. Calibration thicknesses were 0.06, 0.09, 0.17, 0.30 and 0.39 mils

Conclusion

This study shows that the handheld Agilent 4100 ExoScan FTIR spectrometer can be used to measure the thickness of aircraft epoxy primers on aluminum. The excellent linear agreement of the calibration shows that an accurate prediction can be made using this technique. Additionally, the system is sensitive to small changes in primer thickness, even at thin coatings typically used in aircraft applications.

In addition to the 4100 ExoScan FTIR, Agilent also offers the 4200 FlexScan FTIR. The 4100 ExoScan and 4200 FlexScan both provide easy, handheld FTIR analysis, but with slightly different form factors. The 4200 FlexScan has the same optical components as the 4100 ExoScan, but the optics and electronics are separated by a cable. This make the handheld component smaller, while still providing the spectroscopic performance needed for a wide variety of applications. The 4200 FlexScan has a 3 pound optical head attached to a 4 pound battery and electronics pack. Although the form factor is different, use of the two systems, including the software, is identical. While the 4100 ExoScan provides an integrated, compact package, the 4200 FlexScan has a smaller size to fit into spaces with tight clearances.

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