Excellence in Science

Application News

No. A627

Fourier Transform Infrared Spectrophotometer

Differentiation of Resins in Carbon Fiber Reinforced Plastics (CFRP) by FTIR

Carbon fiber reinforced plastic (CFRP) is a composite material which is produced by strengthening a resin with carbon fiber, and has the outstanding features of light weight in combination with high strength and high rigidity. In recent years, CFRP has been applied in a wide range of fields, including transportation equipment such as aircraft and automobiles and civil engineering and construction.

The main type of CFRP used in aircraft and high-speed railway applications is thermosetting CFRP, in which a thermosetting resin is hardened by heating. Epoxy resin is a representative base material. Although thermosetting CFRP has extremely high strength and rigidity, problems include (1) the time required for production, (2) high difficulty of secondary processing, as thermosetting CFRPs do not exhibit deformation behavior like that of steel and plastics, and (3) difficulty of recycling and high production cost.

On the other hand, application of thermoplastic CFRPs to automotive structural parts is also under study. Thermoplastic CFRPs utilize resins which soften when heated, and the representative resins used in this type span a wide range, including polyamide (PA), polycarbonate (PC), polyphenylene sulfide (PPS), and others. While the thermoplastic CFRPs are inferior to thermosetting CFRPs in terms of strength and rigidity, their mass producibility is excellent and secondary processing is easy. Moreover, because recycling is possible, production costs can also be held to a comparatively low level. For these reasons, thermoplastic CFRPs have attracted considerable attention as new materials for realizing weight reduction in mass production-type automobiles.

Because the resins used in CFRPs can be differentiated easily by analysis by Fourier transform infrared spectrophotometry (FTIR), FTIR is an effective tool for quality control when determining the resin components of CFRPs before recycling. In this article, thermosetting and thermoplastic CFRPs were measured by FTIR and their component resins were differentiated.

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Differentiation of Resins in CFRPs

Here, an epoxy resin (EP) CFRP was measured as a thermosetting CFRP, and polyether imide (PEI), polyamide 6 (PA6), and polyether ether ketone (PEEK) were measured as thermoplastic CFRPs. Fig. 1 shows the appearance of the CFRPs.

The measurements were conducted using a Shimadzu IRSpirit™ Fourier transform infrared spectrophotometer and QATR™-S single-reflection ATR accessory. Fig. 2 shows the appearance of the IRSpirit and QATR-S, and Table 1 shows the measurement conditions. Measurements using the QATR-S are conducted by placing the sample in tight contact with the ATR prism surface. Quick measurement is possible, as no special pretreatment is necessary. Moreover, because the QATR-S is designed to be flush with the sample compartment on all sides, a wide top-sampling surface is available, enabling measurement of large-area samples without cutting.

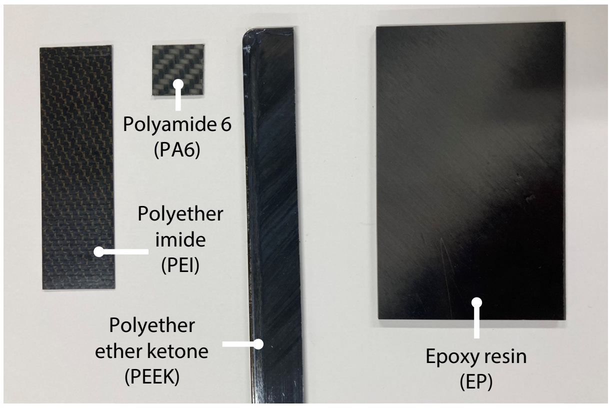

Fig. 1 Appearance of CFRP Samples

Fig. 2 Appearance of IRSpirit™ and QATR™-S

Table 1 Measurement Conditions

Instruments	: IRSpirit (KBr window plate) QATR-S (wide-band diamond prism)
Resolution	: 4 cm^{-1}
Accumulation	: 10 times
Apodization function	: Happ-Genzel
Detector	: DLATGS

Fig. 3 to Fig. 6 show the infrared (IR) spectra and the spectrum search results for the CFRPs using epoxy resin, polyether imide, polyamide 6, and polyether ether ketone, respectively. The red lines show the measurement results, and the black lines show the spectrum search results. The library provided with IRSpirit as a standard feature was used in the spectrum searches. In all cases, the search results were in agreement with the resins used.

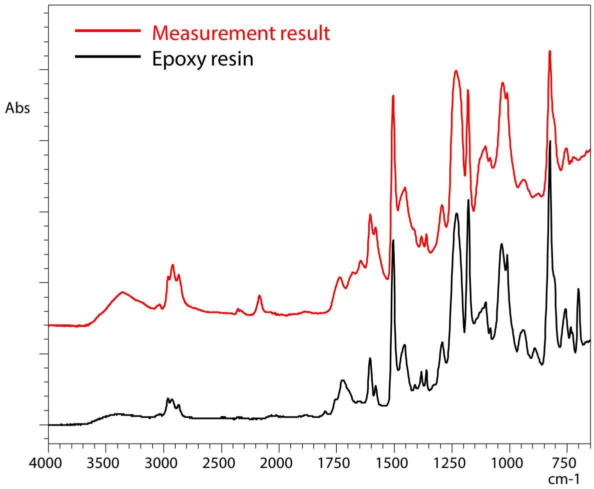

Fig. 3 IR Spectrum of Thermosetting CFRP Using Epoxy Resin

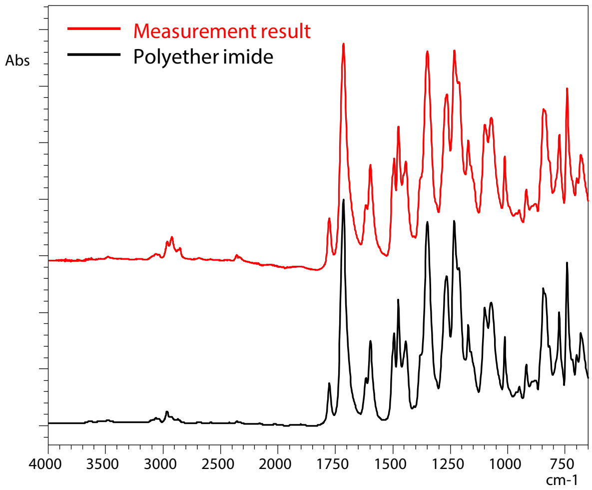

Fig. 4 IR Spectrum of Thermoplastic CFRP Using Polyether Imide

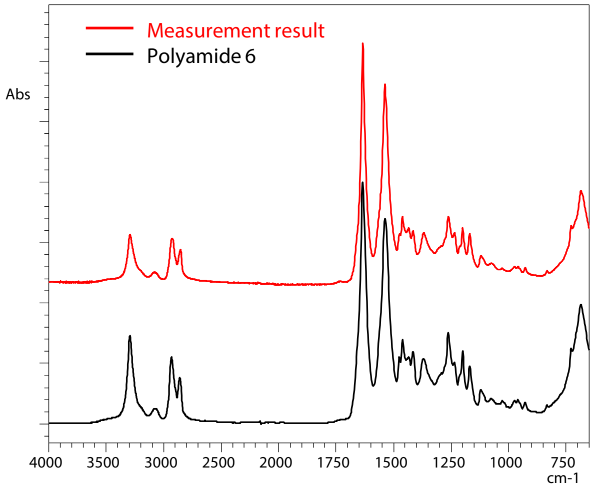

Fig. 5 IR Spectrum of Thermoplastic CFRP Using Polyamide 6

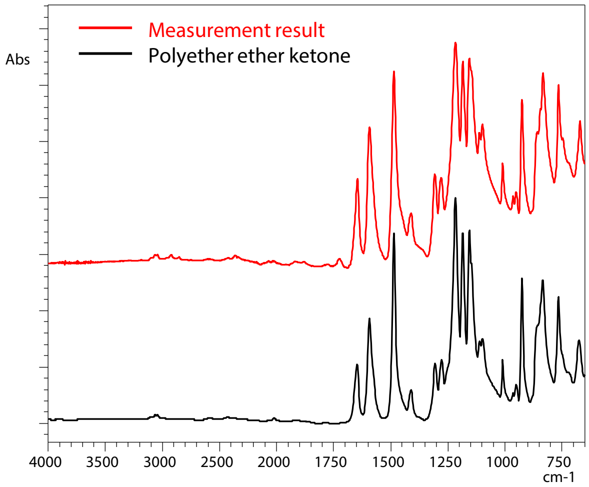

Fig. 6 IR Spectrum of Thermoplastic CFRP Using Polyether Ether Ketone

Conclusion

Differentiation of the resins used as base materials of a thermosetting and thermoplastic CFRPs was conducted using a Shimadzu FTIR Fourier transform infrared spectrophotometer. Simple qualitative analysis of the resin components was possible by using the library provided with the FTIR as a standard feature. This technique is useful for quality control when recycling CFRPs.

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