Application Note

Materials

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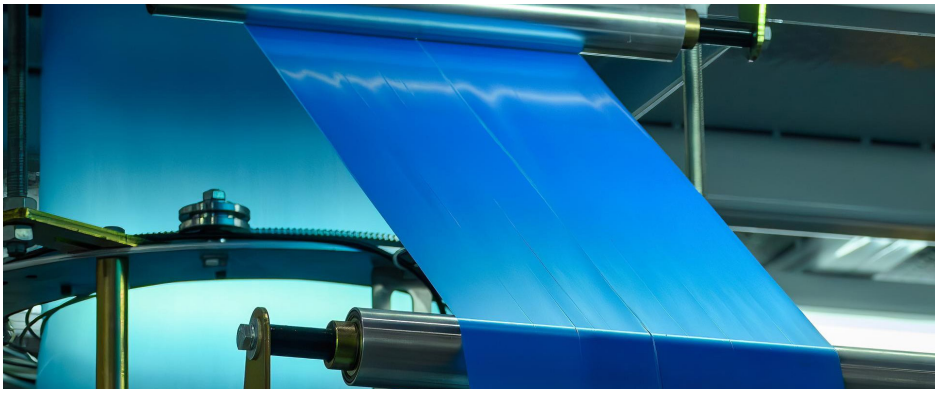
Thin Multilayer Analysis Using the Agilent 8700 LDIR Chemical Imaging System

Rapid micrometer-scale measurement of layer thickness and composition identification in laminated materials



Author

Wesam Alwan
Agilent Technologies, Inc.

Introduction

Multilayer laminate materials represent a structurally and chemically complex system. They often comprise several distinct polymer layers that are engineered for specific functional roles, despite having total thicknesses of only a few hundred microns. Each layer contributes unique properties such as mechanical strength, barrier performance, or environmental protection, depending on its chemical composition and thickness. Accurate identification and measurement of these thin layers is therefore critical, as defects or deviations in layer thickness can compromise product integrity. Weaknesses can cause failures through damage, potentially resulting in safety issues for the user.

Precise mapping and micrometer-scale thickness analysis is essential during the development, quality control, and troubleshooting of multilayer materials. The Agilent 8700 Laser Direct Infrared (LDIR) chemical imaging system offers a powerful solution for this application. By combining IR spectroscopy with high-resolution imaging, the system enables chemical identification and visualization of polymer layers with exceptional spatial detail. Enhanced by the intuitive Agilent Clarity software, the 8700 LDIR delivers a fast and effective workflow for multilayer material characterization, addressing key needs in quality assurance, failure analysis, and reverse engineering.

Experimental

Samples

To assess the performance of the 8700 LDIR chemical imaging system for multilayer analysis, the following three samples were examined:

1. **Sample 1** – A multilayer laminate composed of three known polymers: polypropylene (PP), polystyrene (PS), and polyethylene (PE). This sample was used to generate a reference spectral library using the Clarity software.
2. **Sample 2** – A second multilayer sample containing three "known" but unlabeled layers, composed of the same polymer types as sample 1. This sample was used to validate the reference spectral library.
3. **Sample 3** – A multilayer lithium-ion battery separator with a total thickness of approximately 25 ± 2 µm. This sample was used to demonstrate the system's capability for analyzing ultra-thin polymer structures.

Samples 2 and 3 were characterized using the library generated from analyzing sample 1.

Sample preparation

Samples were prepared using the Agilent laminate holder (Figure 1) and Agilent sample planer (Figure 2), a precision microtome tool designed for fast and reproducible cross-sectional preparation. Each multilayer laminate sample was securely clamped within the holder and sliced to expose a flat surface for imaging. The laminate holder includes sacrificial support surfaces that ensure optimal support during sectioning, preventing bending, folding, or delamination of layers. The entire preparation process is completed within minutes, offering a significant time advantage over traditional resin embedding and polishing methods that typically require several hours and specialized expertise.

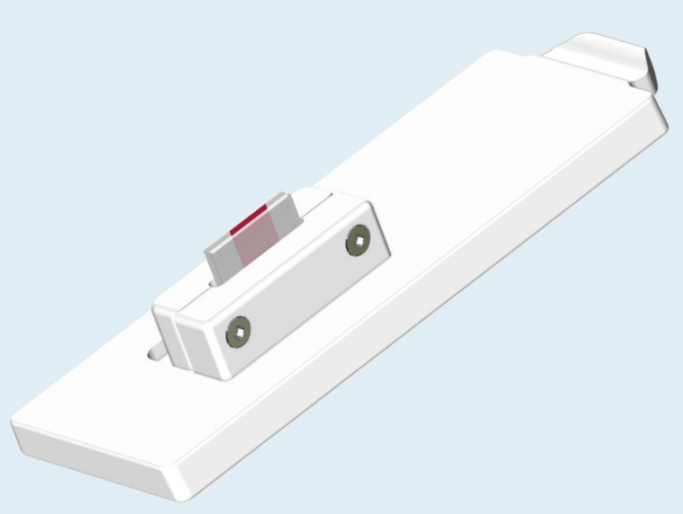


Figure 1. Agilent 8700 LDIR laminate sample holder. For sample preparation using the sample planer (shown in Figure 2), the multilayer laminate sample is placed between the transparent sacrificial laminate strip.

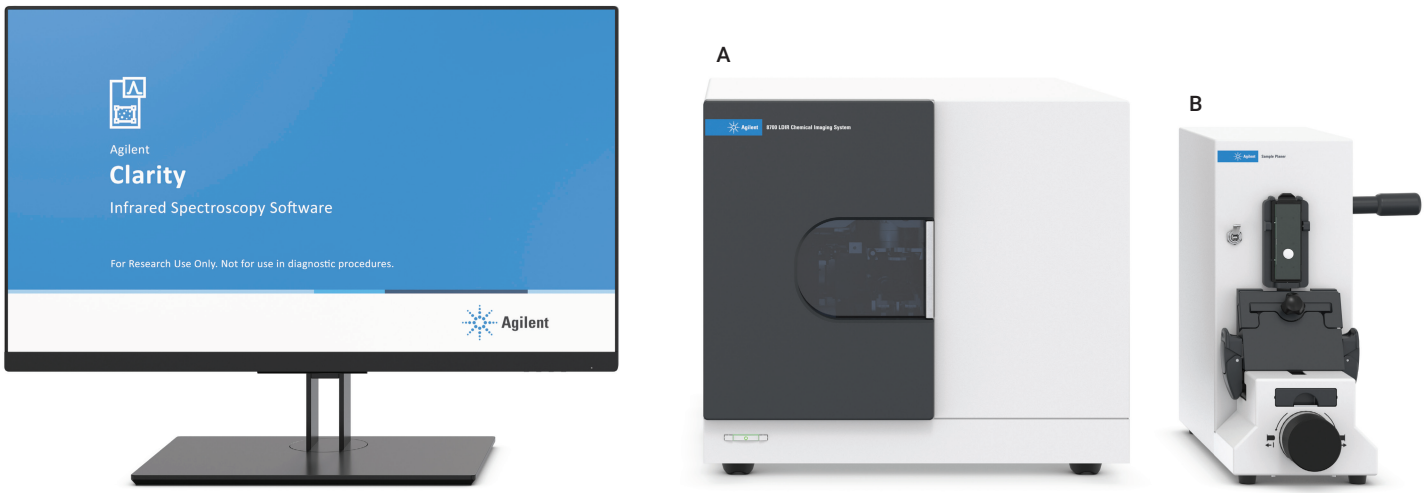


Figure 2. The Agilent 8700 LDIR chemical imaging system with monitor (A) and Agilent LDIR sample planer (B). The sample planer accessory simplifies sample preparation of laminated material cross-sections by creating a consistent, flat surface for analysis by LDIR.

Results and discussion

User-generated spectral library

Following sample preparation, the 8700 LDIR high-magnification visible camera provided an overview of the laminate structure of sample 1, revealing three distinct layers. The total thickness of the sample and each layer was measured using the Clarity software ruler feature.

As shown in Figure 3, the total thickness of sample 1 based on the visible image was measured to be 150 µm (layer 1: 50 µm; layer 2: 50 µm; layer 3: 50 µm). A high-resolution IR image was then acquired at 1,442 cm^{-1} with a 1 µm pixel size, enabling detailed visualization of the layer morphology under infrared light (Figure 3).

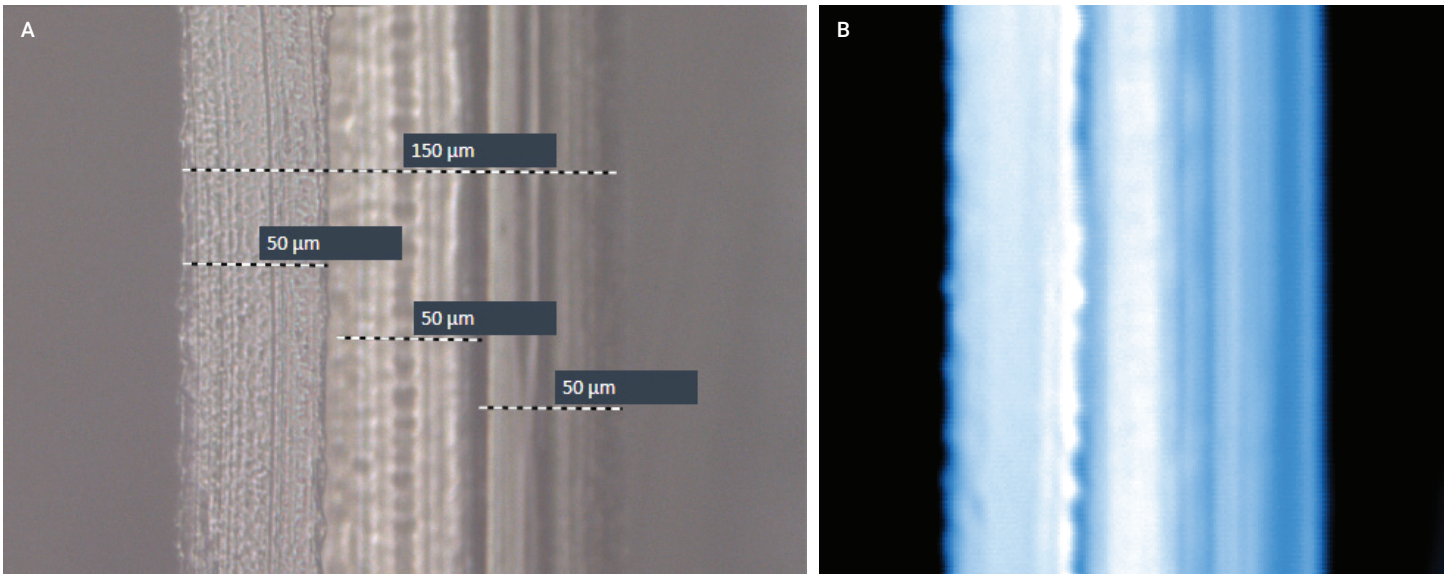


Figure 3. Agilent 8700 LDIR analysis of sample 1. (A) High-magnification visible image. (B) Infrared image at 1,442 cm^{-1}.

IR spectra were collected across sample 1 using the Clarity software's line profile feature, which automatically acquires single-point spectral data along a selected length (150 µm). For sample 1, spectra were manually reviewed, and three distinct IR spectral features were observed corresponding to the three known layers (PE, PS, and PP), as shown in Figure 4.

Since the polymer type of each layer was known, a spectrum for each layer was added to a user-generated library in the Clarity software and named according to its chemical identity. Spectra acquired from the laminate layers of samples 2 and 3 were then identified through comparison with this reference library. The Clarity software's intuitive interface supports simple library creation and management and provides a Hit Quality Index (HQI) score reflecting the similarity between sample and reference spectra.

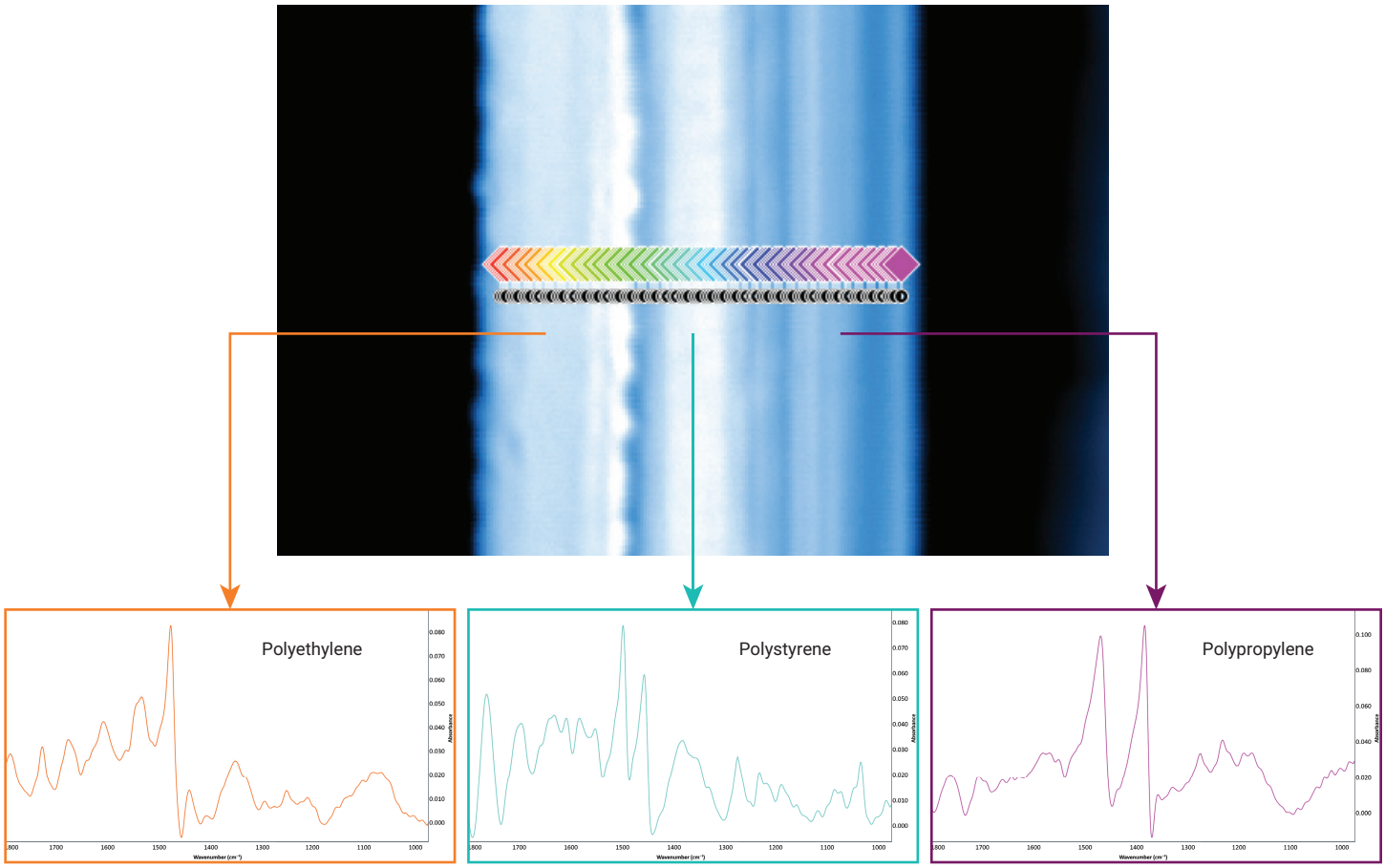


Figure 4. Line profile analysis showing 100 single-point spectra collected automatically across the laminate (sample 1). From left to right, the three distinct spectra corresponding to PE, PS, and PP.

Analyzing unknown samples

The same workflow was applied to samples 2 and 3, including visible imaging, IR imaging, and line profile spectral acquisition.

The thickness of sample 2 was measured at 90 µm (layer 1: 25 µm, layer 2: 40 µm, layer 3: 25 µm) and the line profile spectral data were matched against the user-generated library. Layer one was identified as PS (HQI: 0.882), layer two as PE (HQI: 0.938), and layer 3 as PP (HQI: 0.948), confirming high-confidence spectral matching (Figure 5).

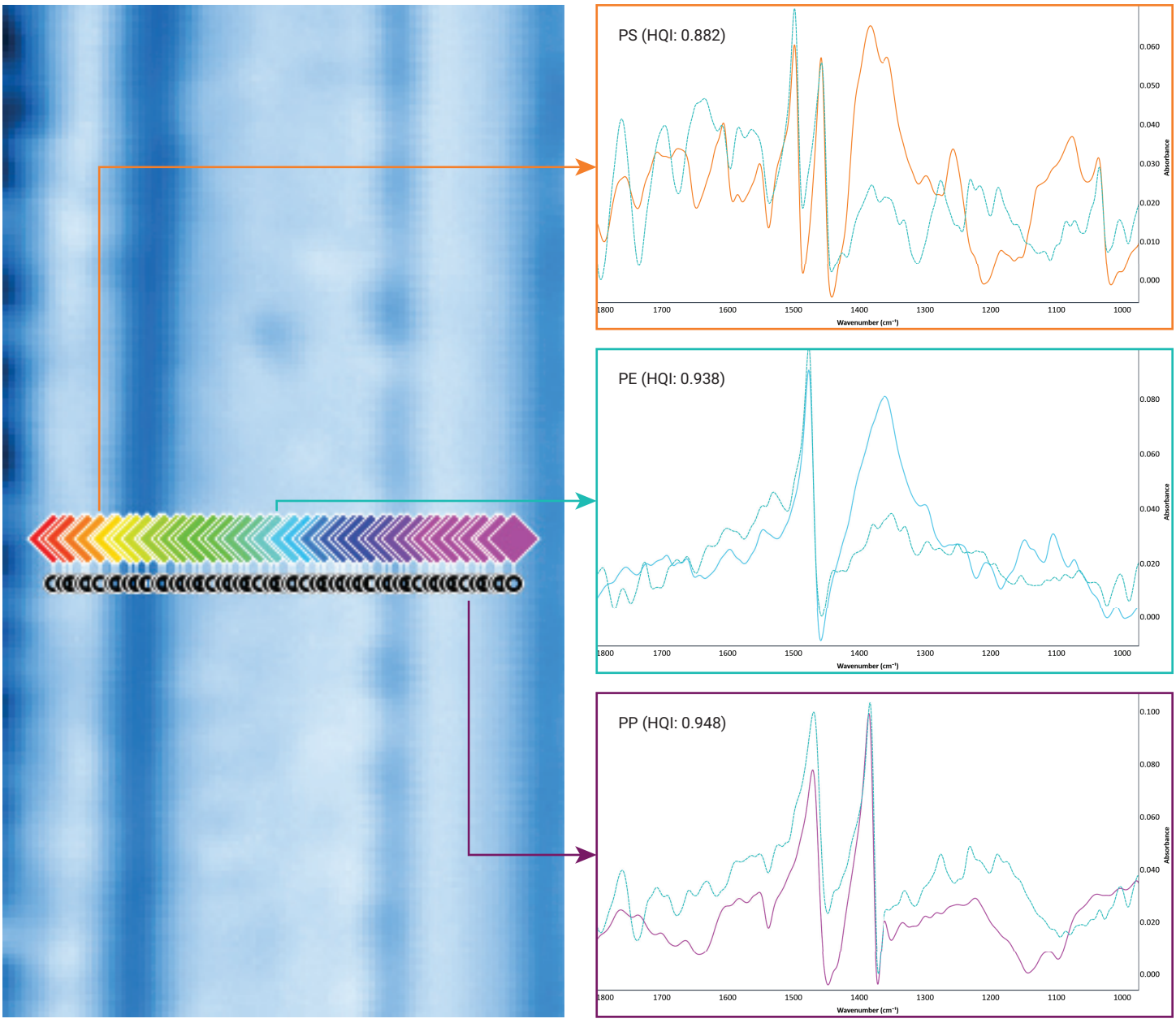


Figure 5. Correct identification of the three layers of sample 2 as PS, PE, and PP, validating the user-generated spectral library.

Sample 3 is a commercially available lithium-ion battery separator, reported by the manufacturer to consist of three layers (PP, PE, and PP) with a total thickness of 25 µm. As shown in Figure 6, the 8700 LDIR measured the combined thickness of the laminated layers as 29 µm. Despite the thin profile, all three layers were correctly identified, with HQIs of 0.871 for layer 1 (PP), 0.843 for layer 2 (PE), and 0.800 for layer 3 (PP).

These results demonstrate the 8700 LDIR system's capability to resolve and identify multilayer structures with high spatial and spectral resolution, even in samples with sub-10 µm layers.

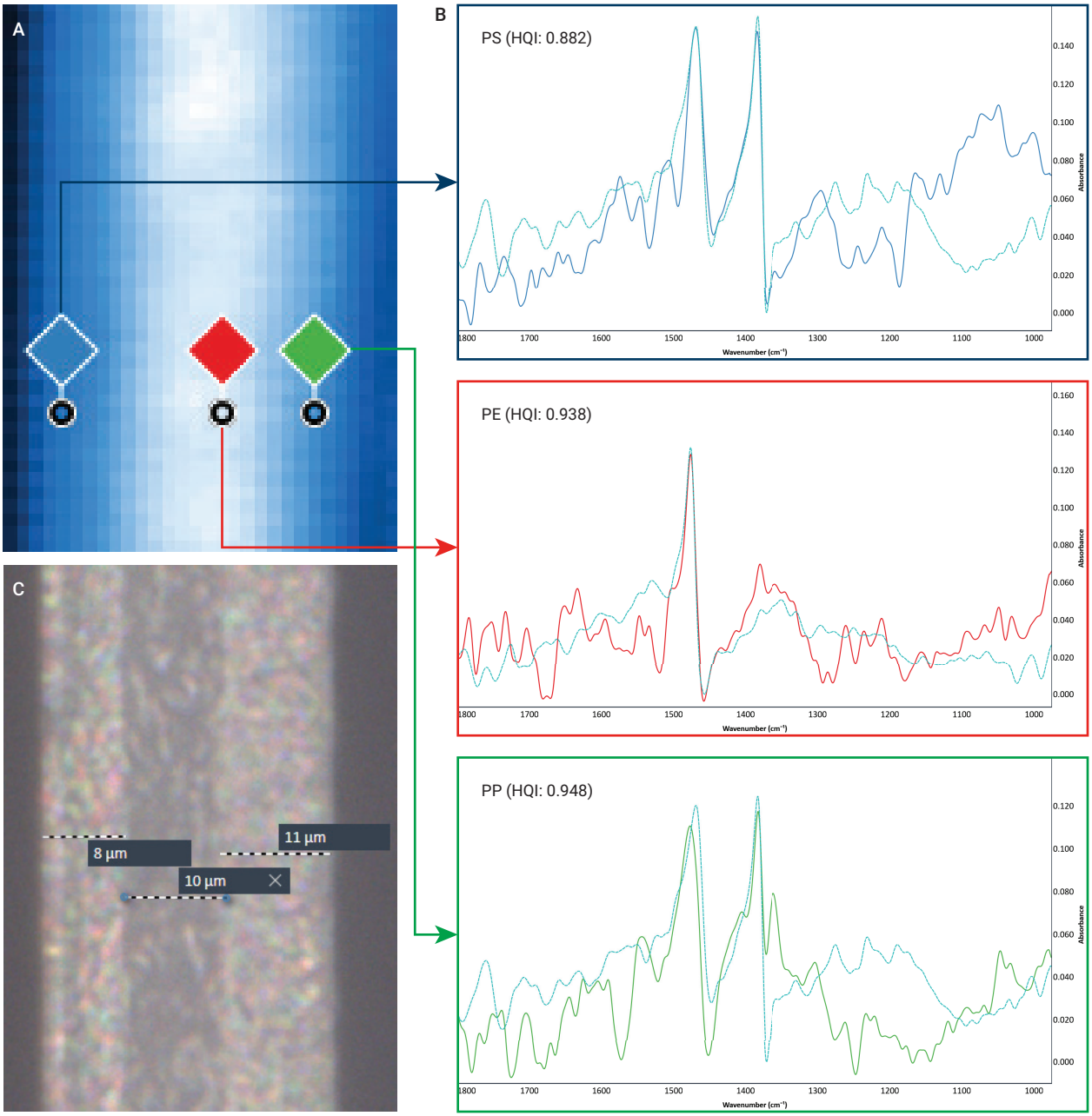


Figure 6. (A) Infrared image of lithium-ion battery separator consisting of three ultra-thin layers. (B) Single-point spectra obtained from the IR image showing the acquired spectra as a solid line and the matched library spectra as a dashed line with HQI scores.
(C) The visible image showing the thickness of each layer.

Conclusion

The Agilent 8700 LDIR chemical imaging system provides a powerful, non-destructive solution for multilayer analysis across diverse applications ranging from food packaging to battery separators. By combining a laminate holder, high-magnification imaging, IR imaging, and line profile spectral collection, the method delivers clear insights into layer thickness, morphology, and material composition. The ability to quickly build custom spectral libraries within the Agilent Clarity software further enhances its utility, especially for identifying unknown materials or contaminants in multilayer materials.

The 8700 LDIR multilayer analysis workflow supports both R&D innovation in advanced materials and routine quality assurance across different industries.

Further information

- Agilent 8700 LDIR chemical imaging system
- Agilent Clarity Software
- Microplastics Technologies FAQs
- Microplastics Analysis in Water
- Microplastic Characterization in Infant Formula

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