Spectrochemical Analysis and Hyperspectral Imaging of Latent Fingerprints

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Summary

This work has been undertaken to gain an understanding of the chemical composition of latent prints so that new methods of developing fingerprint images can be explored. Children's fingerprints have been an important aspect of this work. Additionally, methods of imaging fingerprints from electro-optical responses obtained through spectrometers have been investigated[1]. This process is often referred to as hyperspectral imaging.

Introduction

In certain instances latent fingerprints cannot be acquired by existing methods. Frequently caseworkers have reported that the recovery of children's prints at a crime scene is difficult or not possible. Therefore, there is interest in the forensic community to improve understanding of the chemical character of latent fingerprints with an emphasis on children's prints so that current techniques can be modified or new ones developed.

Previous work has been done by gas chromatography/mass spectrometry (GC/MS)[2]. The disadvantage of GC/MS is that it is destructive, and sample acquisition is from a large area and, therefore, is not specific to small individual heterogeneous components. Infrared analysis, however, can be used noninvasively on small areas of the ridge material to identify specific chemical components.

Materials and Methods

Adult and children's prints have been studied while on aluminum coated microscope slides. Microscopical Raman and IR spectroscopy have been used to acquire spectra. IR by reflection-absorption analysis has the greater sensitivity, and this method was adopted for our continuing work. The IR spectra were collected at 4 cm^{-1} resolution and averaged for128 scans. A Thermo Nicolet Magna 560 FT-IR with a Nic-Plan^{TM} microscope was used.

The visible, near-infrared (NIR), and mid-infrared (IR) spectral regions have been used with corresponding spectrometers for hyperspectral imaging. The visible and the NIR work covered whole fingerprints. Microscopes have been used for the IR for imaging small areas of single ridgelines and whole prints. To image whole fingerprints, line scanning has been conducted by using a linear array detector and moving the microscope stage.

Results

The study has included analysis ranging from very young children to adults. Figure 1 shows a spectrum obtained from a four-year-old boy's eccrine fingerprint. The photomicrograph showing the material is not clear, because little deposit is present. The spectrum indicates the lack of material by weak peak intensities. The net intensity in the C-H stretching region is approximately 0.8 % transmittance. The water vapor and carbon dioxide peaks from the ambient air are on the same order of magnitude. Unsaturation in the carbon chain is observable near 3014 cm^{-1}. Unsaturation has been commonly observed in children's prints[2].

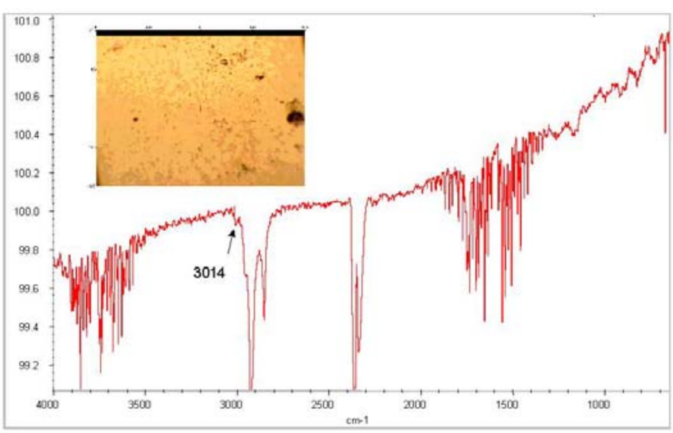

Figure 1. IR spectrum and photomicrograph of a four-year-old boy's eccrine fingerprint.

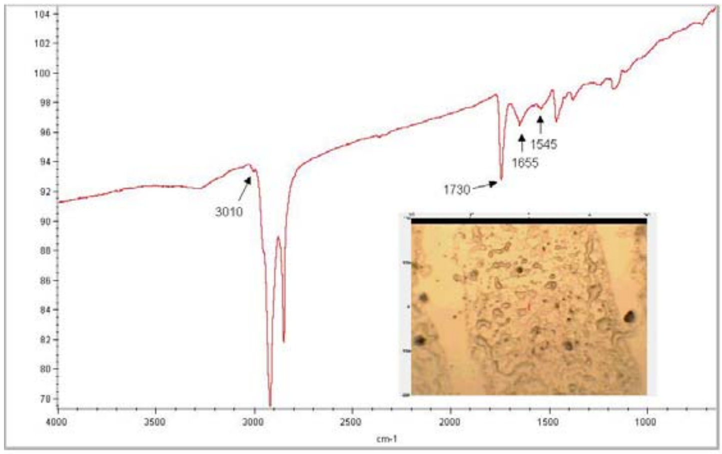

Figure 2. IR spectrum and photomicrograph of a nine-year-old boy's sebaceous fingerprint.

The ridgeline is much more distinct from a nine-year-old boy's sebaceous print as shown in Figure 2.

The line can be observed diagonally from the top left to the bottom right of the inserted photomicrograph. The stronger peaks in the improved spectrum reflect the presence of additional material. The C-H stretching region near 3000 cm^{-1} shows a net intensity of about 25% transmittance. The carbonyl band near 1730 cm^{-1} from a fatty acid ester is clearly observable. The bands near 1655 and 1545 cm^{-1} are the amide I and II bands from protein material. These results indicate that as children get older, they show increasing amounts of sebum even prior to physical signs of puberty.

With successful acquisition of spectra obtained from fingerprint material, spectral images of latent fingerprints were investigated. Initial work was successfully conducted using visible and NIR imaging spectrographs. Figure 3 shows a NIR image plot of an adult female forefinger. The liquid crystal tunable filter spectrograph was scanned over the range of 805-

Figure 3. Adult Female NIR image.

1000 nm at 2 nm increments and imaged with a charge-coupled-devise (CCD) array detector with resolution of 384 x 256 pixels.

Because of the additional chemical information provided by the mid-IR, this region has been used for our continuing work. Fourier transform IR systems with microscopes were used to study areas of approximately $0.1mm^2$ to $2.9cm^2$. Figure 4 shows a 32 cm^{-1} resolution spectrum obtained by a mercury cadmium telluride linear array detector collected by moving the microscope stage to cover the area of 1.8 x 1.6 cm of a fingerprint.

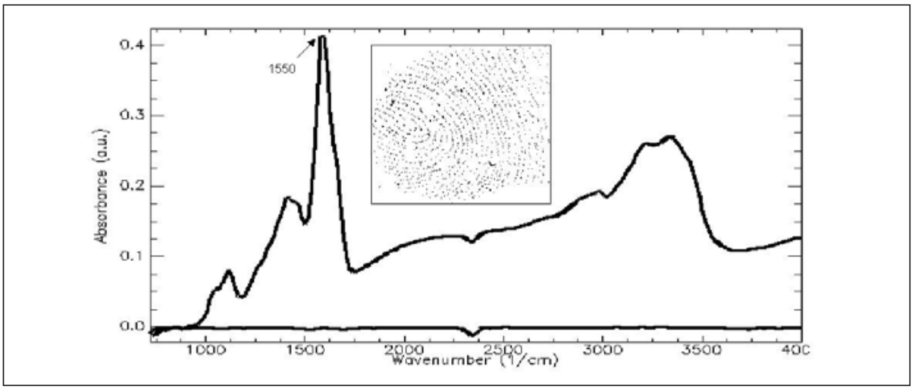

Figure 4. Upper spectrum was obtained from a point on FT-IR hyperspectral image. Lower spectrum was obtained in a space between ridgelines. Insert is the image produced from 1550 cm^{-1} absorbance intensities.

Conclusion

Successful results have been acquired in collecting spectra and images from latent fingerprints. Additional studies are required to determine the chemical composition variation within children and within adults. Further work is ongoing to develop instruments for rapid acquisition of IR hyperspectral images in the laboratory and in the field.

References

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2. M. BUCHANAN, K. ASANO, and A. BOHANON, Chemical characterization of fingerprints from adults and children, *SPIE* Vol. 2941, 89-95, 1997.