FOURIER TRANSFORM INFRARED IMAGING OF COTTON TRASH MIXTURES

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Abstract

There is much interest in the identification of trash types comingled with cotton lint. A good understanding of the specific trash types present can lead to the fabrication of new equipment which can identify and sort cotton trash found with cotton fiber. Conventional methods, including the High Volume Instrument (HVI) and the Advanced Fiber Information System (AFIS), do not yield specific data on the origin of the cotton trash. Formerly, spectroscopic analysis of cotton trash has been successfully applied to identify pure trash types. It is the goal of this study to determine the feasibility of using Fourier Transform Infrared (FT-IR) imaging to identify botanical and field trash types.

Introduction

FT-IR imaging became mainstream in the scientific community in 2000 (Šašic and Ozaki, 2010). However, its utility in the textile community has just recently become apparent. The attenuated total reflectance (ATR) accessory is popularly used, especially in macro-sampling (Sellors et al., 2010). The advantage of this technique is little to no sample prep, short analysis time and accuracy. The price garnered for cotton is directly influenced by the trash comingled with it. Compounding the issue is that trash can be found present with cotton lint during harvesting, ginning, and processing. Thus, identifying trash types would affect the upstream and downstream aspects of the cotton industry. Conventional methods to characterize trash such as the Advanced Fiber Information System (AFIS), the High Volume Instrument (HVI) or the Shirley Analyzer (SA) do not yield information about the specific trash type present. Recently, Himmelsbach and co-workers reported on the use of FT-IR spectroscopy to identify pure forms of botanical and field trash types (Himmelsbach et al., 2006). The work being presented herein is aimed at defining the capabilities of the FT-IR imaging system to analyze cotton trash mixtures. Specifically, the technique combines the spatial and spectral information to be used to identify botanical trash types and field trash types.

Experimental

All FT-IR images were collected on a Bruker FT-IR imaging system with an 8 cm^{-1} resolution with 64 air background scans with 64 sample scans. A Bruker Vertex spectrometer equipped with a focal plane array (FPA) detector was also employed in this study. The spectral range scanned was 900 - 4000cm^{-1}.The ATR crystal consisted of zinc selenide (ZnSe). The ATR accessory was centrally located in the Imaging macro-chamber (IMAC). To run the sample on the ATR crystal in the IMAC (Figure 1): the thin samples (a few millimeters) of botanical and field trash types were mounted and taped to the crystal, with the screw tightened down to ensure good contact with the sample and the screw. The IMAC shown in Figure 1 was used in all experiments. First, a 2-D image was collected for each cotton mixture. Next, a spectrum was extracted from the 2-D image from areas of high intensity. The analysis time for each sample was ~5 minutes. Higher scans times were investigated, but no increase in resolution was observed.

Figure 1. IMAC fitted with an ATR accessory and FPA detector (not shown).

Results and Discussion

Figure 2 depicts the comparison of leaf and hull botanical trash. On the 2-D image (Figure 2a1.) the white arrow highlights an area of high intensity based on the color legend with pink being the highest intensity and blue being the lowest intensity. When the spectrum was extracted from that site it correlated well with that of leaf trash (Figure 2,b1.). Similarly, the same 2-D image was used but the red arrow highlighted another area of high intensity. When the spectrum was extracted from that site it correlated well with that of hull trash. When comparing the 2 extracted spectra the hydroxyl region at 3100-3300 cm^{-1} and the C-H at 2900-2800 cm^{-1} correlated well between the hull and leaf trash (Foulk et al., 2004). This is not surprising since the leaf and hull trash are both cellulose-based. However, it was revealed that the peaks in the fingerprint region in FT-IR (1450-1100 cm^{-1}) revealed slight differences in the spectra for hull and leaf trash. These fingerprint peaks coincide with many contributions for the C-H region. In Figure 3,a1., botanical trash was compared to field trash with emphasis on a plastic grocery bag and leaf trash was compared. On the 2-D image the white arrow highlights the grocery bag. The well pronounced 2 peaks in the C-H 2900-2800 cm^{-1} region and the C-H peaks in the 1500-1300 cm^{-1} definitely confirm the presence of polyethylene (Himmelsbach et al., 2006). The leaf trash again was characterized by the C-H and O-H peaks. Since the origins of the compounds were different, the spectral identity of each was clearly unique.

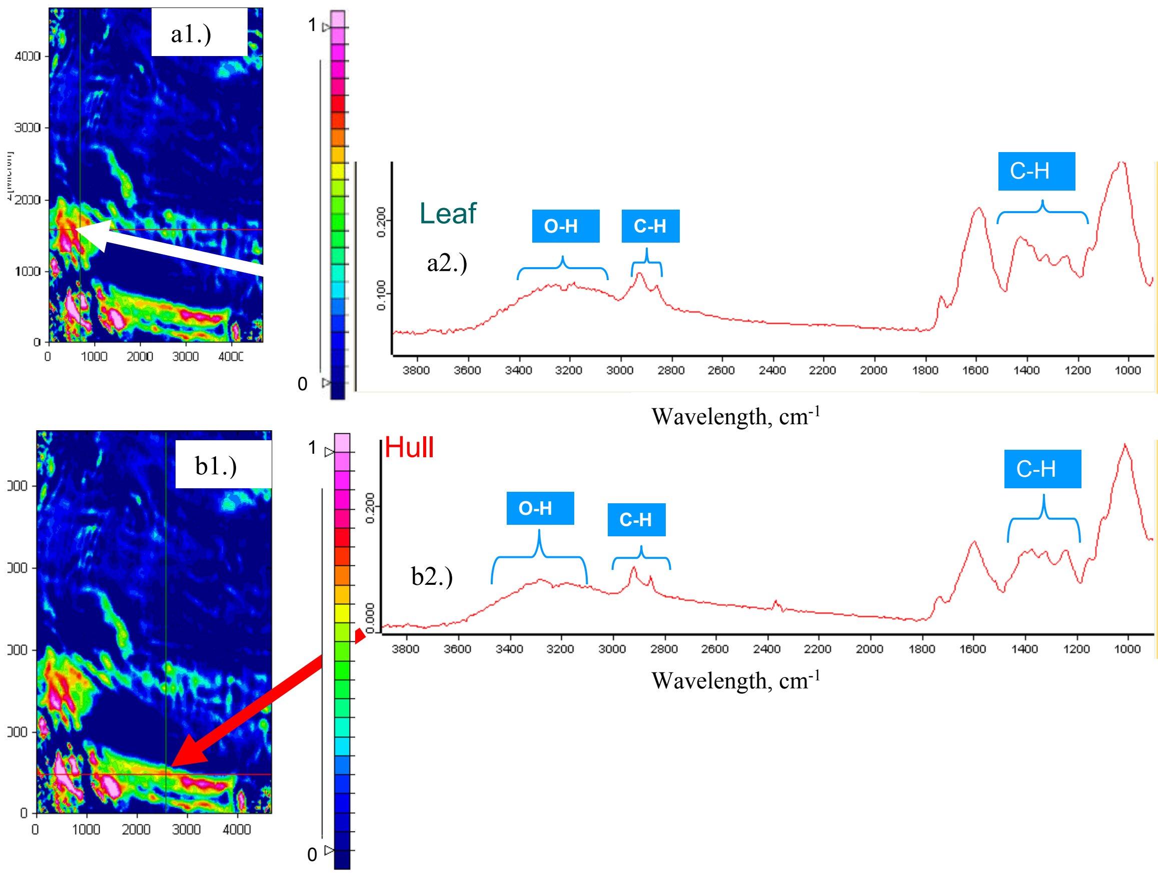

Figure 2. Comparison of leaf and hull trash using FT-IR imaging. a1.) FT-IR image focusing on spatial position of leaf trash with white arrow. a2.) The corresponding leaf FT-IR extracted spectrum b.1) FT-IR image focusing on spatial position of hull trash with red arrow. b2.) The corresponding extracted FT-IR spectrum was for hull trash.

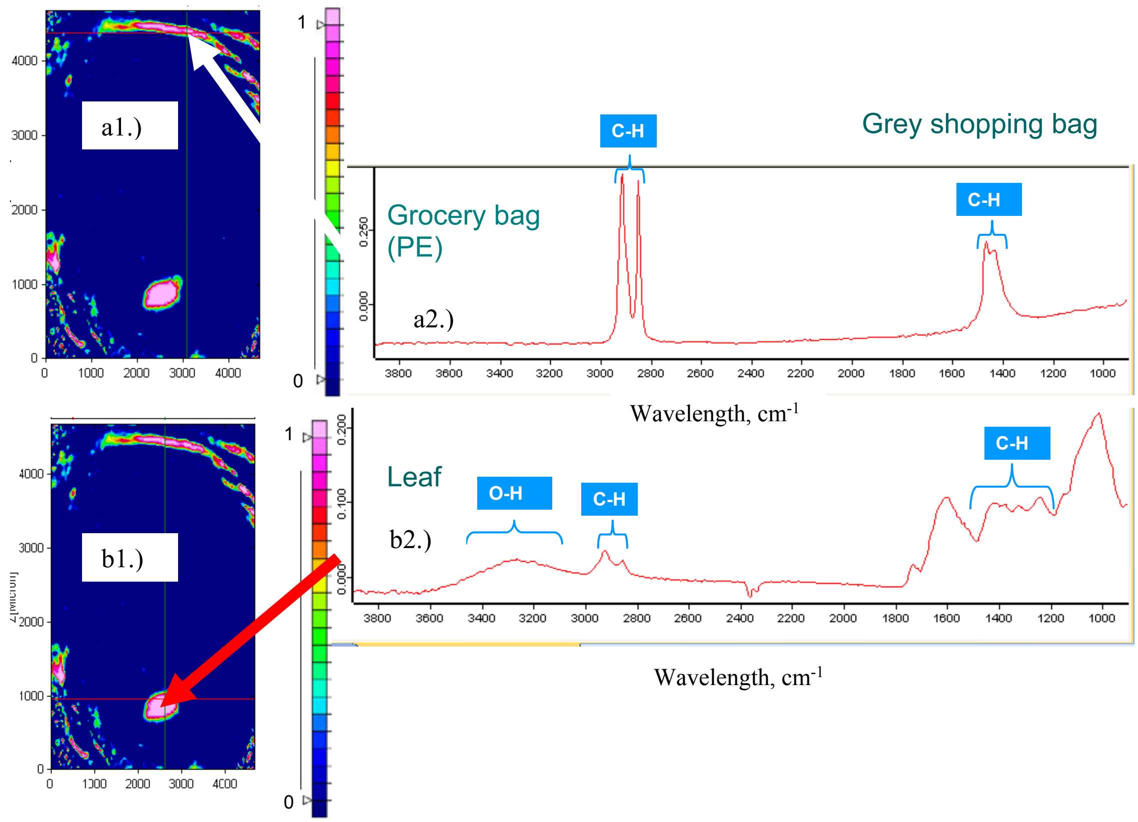

Figure 3. Comparison of plastic grocery bag and leaf trash using FT-IR imaging. a1.) FT-IR image focusing on a plastic grocery bag with white arrow. a2.) The corresponding plastic grocery bag FT-IR extracted spectrum b.1) FT-IR image focusing on leaf trash with red arrow. b2.) The corresponding extracted leaf FT-IR spectrum.

Conclusions

The utility of FT-IR imaging has been demonstrated by identifying characteristic peaks that correlate to leaf, hull, and grocery bag trash. Botanical trash and field trash were uniquely and accurately identified in a relatively short analysis time. FT-IR imaging can be used in the textile community to specifically identify contaminants comingled with cotton fiber, particularly after harvesting, ginning, or processing. This method may enhance the overall quality of cotton and improve its economical cost.

Disclaimer

The use of a company or product name is solely for the purpose of providing specific information and does not imply approval or recommendation by the United States Department of Agriculture to the exclusion of others.

References

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