COTTON TRASH CHARACTERIZATION WITH FLUORESCENCE SPECTROSCOPY

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Abstract

Seed cotton contains a number of trash components originating from botanical and non-botanical sources picked up from the field during harvesting. An imaging method with potential to aid in cotton trash classification is fluorescent imaging. The first step in development of a fluorescent imaging system is to characterize individual types of cotton trash with fluorescence spectroscopy in order to determine their optimum excitation/emission wavelength bands so appropriate excitation sources can be chosen. A group consisting of five types of botanical trash (bark, bract, brown leaf, green leaf, seed coat) and three types of non-botanical trash (paper, bale packaging, twine) was chosen, in addition to lint. Each cotton trash type and lint were subjected to a fluorescence spectroscopy analysis to determine their optimal excitation and emission wavelength peaks. Future studies will focus on developing the imaging system, analyzing cotton trash types with the imaging system for unique identifiers from a number of color models, and their potential for classification.

Introduction

In the US, the primary method of cotton harvesting is with cotton strippers, while in some other countries, cotton is harvested manually due to the availability of cheaper labor. Harvested seed cotton containing botanical and non-botanical trash picked up during harvesting is transported to gins where it undergoes cleaning. Following cleaning, there still remain smaller trash particles admixed with lint. Current methods for quality control include human classers and instruments, like the HVI. Grades assigned by human classers are more subjective than those assigned by instruments. The HVI computes the total area covered by cotton trash in samples under observation, however it lacks the ability to provide information regarding the types of trash detected (Wakelyn et al., 2007).

To provide more detailed information regarding cotton trash differentiation, various techniques have been utilized, mainly based on spectroscopic and imaging methods. In particular there exists a large body of work focused on using the Fourier-Transform (FT) spectroscopy to measure the light absorption measurements of cotton samples, and then follow through with analysis of characteristic functional groups and whether these characteristics can be used to separate trash into different categories. Allen et al. used FT-spectroscopy to examine the effects of heat and size reduction on stem and leaf particles obtained during gin processing, but was unable to discern individual trash types (Allen et al., 2006). Himmelsbach et al. used the technique in conjunction with Attenuated Total Reflectance to obtain spectra of several trash types from botanical and non-botanical sources and compare it with the reference database. High correlation values were achieved between Pima cotton and upland cotton trash, but the accuracy diminished when a mixture of varieties was used (Himmelsbach et al., 2006). The second approach to cotton trash identification was used by Xu et al. who constructed a color imaging system to acquire images of bark, leaf, inner side of seed coat and hairy side of seed coat (Xu et al., 1999). Application of clustering methods yielded accurate classification rates of 83% for leaf if sum of squares or fuzzy clustering was used, and 95% classification rate if artificial neural networks were used.

The objectives of this study were to study different types of botanical and non-botanical trash commonly found in cotton and to perform fluorescence spectroscopy analysis to find their respective excitation and emission peaks. It is envisioned to use this information in the selection of illumination sources of the fluorescence imaging system.

Materials and Methods

Preparation of Cotton Trash Samples

A total of 8 types of cotton trash from botanical and non-botanical sources, and lint were subjected to analysis. Out of four cultivars (Delta Pine 0912, Delta Pine 1050, PhytoGen 499, FiberMax 1944) from the Fall 2012 harvest, botanical trash (bark, bract, brown leaf, green leaf, seed coat) samples were extracted by hand and were subjected to a grinding procedure lasting for 90 seconds (8000M Mixer/Mill, SPEX SamplePrep, Metuchen, NJ). Non- botanical trash (paper, bale packaging, twine) samples obtained from the cotton gin in Tifton, GA and from local stores were cut into shorter segments.

Fluorescence Spectroscopy Analysis Procedure

From each cotton trash type, a sample weighing 0.05 grams was mixed with 10 ml of dimethyl sulfoxide (DMSO) in a beaker, and the resulting mixture was kept at room temperature for 2 hours. After the elapsed time, the extract was filtered out through a 2.5 µm filter (Whatman 42), and diluted 2:1 with DMSO. Out of the diluted solution, 3.5 ml was removed to a glass cuvette (Starna Cells Inc., Atascadero, CA) with a pipette, which was then placed into the fluorospectrometer (Fluoromax, Horiba, Edison, NJ) holding chamber. The excitation wavelength range was set from 300 nm to 500 nm, while the emission wavelength ranged from 320 nm to 700 nm. The resulting scanned data was visualized with an open source visualization software OpenDX (http://www.opendx.org/).

Results

The matrix scans of botanical trash types (Figure 1) for bark, brown leaf, bract, and green leaf tend to follow a common pattern for all except seed coat, namely they all exhibit a red emission peak. For bark, bract, and brown leaf, the optimum emission peak at 672 nm is achieved by exciting the samples at 430 nm.

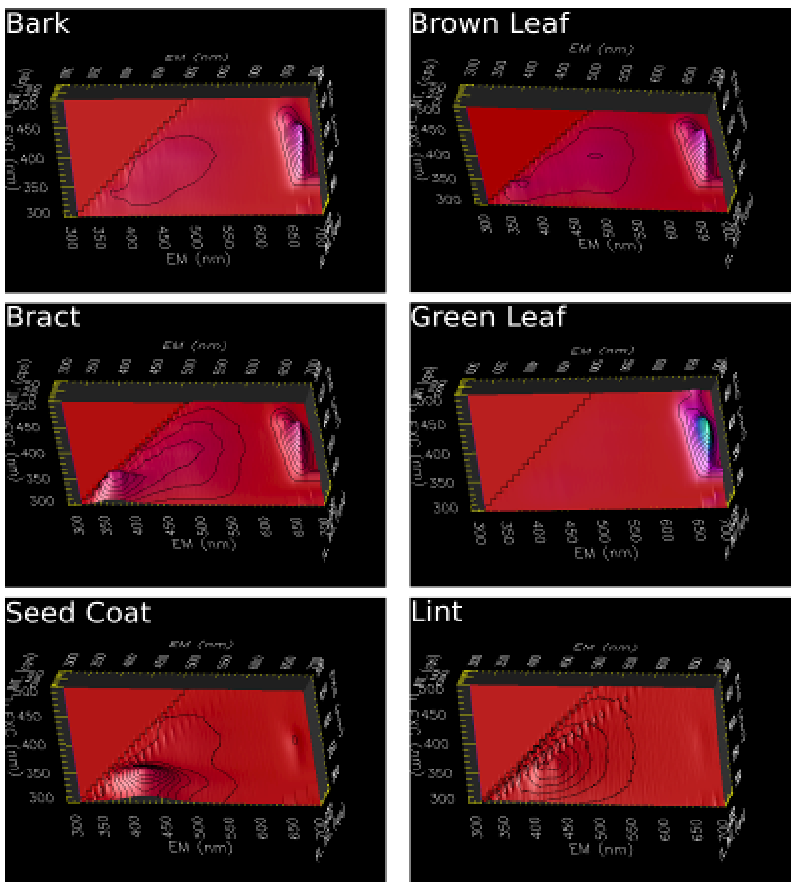

Figure 1: Matrix 3D scans of botanical trash types and lint.

Green leaf also has an emission peak in the red spectral range at 675 nm, with optimal excitation at 410. The spectral scans of these trash types stand in contrast to seed coat, which has an optimum excitation in the UV spectral range at 330 nm, and emission at 461 nm. Respectively, the peak intensity of these trash types varies, with green leaf having the highest intensity at 2.36x10^6 cps, and seed coat at 86,000 cps. The lowest peak intensity is of lint at 16,000 cps, achieved at the excitation of 360 nm and peak emission at 434 nm.

For non-botanical trash (Figure 2), all had optimum excitation in the UV spectral range, with paper at 360 nm, bale packaging at 360 nm, and twine at 300 nm. Paper and bale packaging both had emission peak in the blue spectral range, at 412 nm and 417 nm. In addition to the optimum excitation in the UV range, twine also had optimum emission in the same range at 356 nm. The highest peak emission values were achieved by paper at 3.94X10^6 cps, followed by twine at 482,000 cps, and the lowest by bale packaging at 8,000 cps.

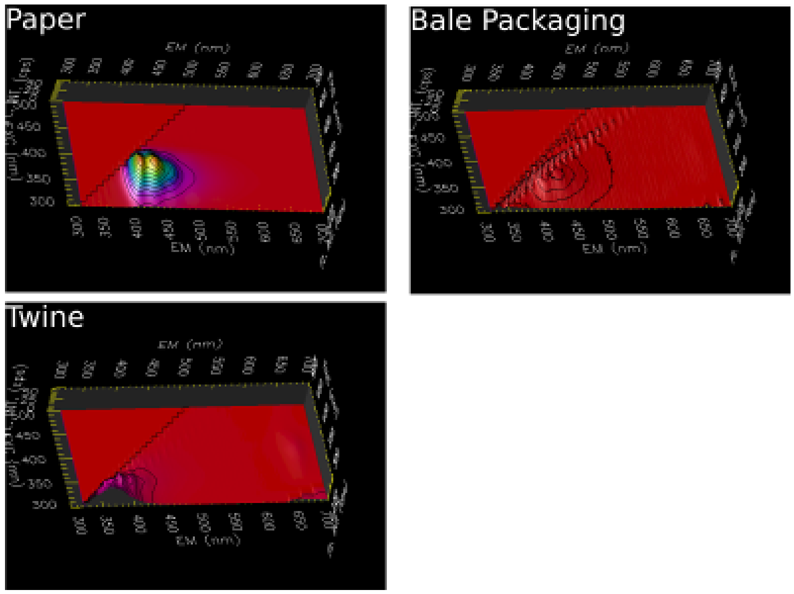

Figure 2: Matrix 3D scans of non-botanical trash types.

Summary

Based on the spectroscopic analysis, out of eight cotton trash types analyzed, four (bark, bract, brown leaf, green leaf) exhibited red fluorescence emission in the region from 671 to 675 nm, due to the presence of chlorophyll. Chlorophyll is a green pigment found in chloroplasts found in chloroplasts of green plants, and the leaf mesophyll cells. On the other hand, seed coat peak emission was at 415 nm, and can be attributed to the presence of several fluorescing pigments, namely ferulic acid, cinnamic acid, and flavonoids. Out of three non-botanical trash types analyzed, paper and bale packaging exhibited peak emission in the blue spectral range at 412 and 417 nm, respectively. In the case of paper, the fluorescing compounds responsible for the phenomena are whitening agents used during wood pulp bleaching in order to make it whiter. Bale packaging peak emission at 417 nm is due to the presence of coloring pigments added to plastic polymers. Twine excitation and emission peak were both in the UV light spectral region at 300 nm and 356 nm, and its existence can be traced back to the presence and lignin and pigments found in the cell walls of jute fibers used to make twine. In summary, four types of botanical trash (bark, bract, brown leaf, green leaf) have optimum excitation in the blue light range, and seed coat and three types of non-botanical cotton trash (paper, bale packaging, twine) have optimum excitation in the UV light range.

Acknowledgments

We are grateful for funding from the Cotton Incorporated and Georgia Cotton Commission, and would like to thank Andy Knowlton from UGA Micro Gin in Tifton, GA for providing us with cotton samples.

References

Allen A., J. Foulk, G. Gamble. Fourier transform infrared spectroscopy analysis of modified cotton trash extracts. 2006. Proc. Beltwide Cotton Conf., San Antonio, p. 3-6.

Himmelsbach, D.S., J.W. Hellgeth, and D.D. McAlister. Development and use of an attenuated total reflectance/fourier transform infrared (ATR/FT-IR) spectral database to identify foreign matter in cotton. 2006. Journal of agricultural and food chemistry. 54(20):7405-7412.

Wakelyn P.J., N.R. Bertoniere, A.D. French, D.P. Thibodeaux, B.A. Triplett, M.A. Rousselle, W.R. Goynes, Jr., J.V. Edwards, L. Hunter, D.D. McAlister, G.R. Gamble. 2007. Cotton Fiber Chemistry and Technology. CRC Press, Boca Raton, FL.

Xu, B., C. Fang, and M.D. Watson. Clustering analysis for cotton trash classification. 1999.Textile Research Journal. 69(9):656-662.