

Photobleaching in cotton fibers dyed using red, yellow, and blue direct dyes during examination with microspectrophotometry (MSP)

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Introduction

- Microspectrophotometry (MSP) is a rapid, nondestructive technique for analysis of color in textile fibers.
- MSP combines microscopy and ultraviolet/visible (UV-Vis) spectroscopy and eliminates the need for time consuming and destructive extraction of dyes from textile fibers when examining colored fibers with traditional techniques such as thin layer chromatography (TLC) or high performance liquid chromatography (HPLC).
- While MSP is generally expected to be a nondestructive evaluation method, a loss of color during analysis, or **photobleaching** can occur.

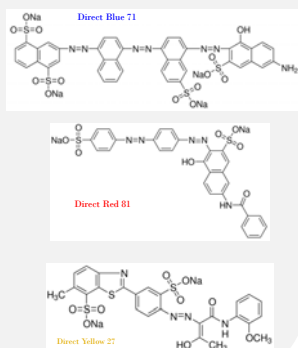
Materials and Methods

Dyeing Experiments:

- Direct dye was applied to cotton fibers in the laboratory.
 - Direct Blue 71,
 - Direct Red 81
 - Direct Yellow 27
- Various dyebath concentrations were used.
 - 0.05 % m/v, 0.033 % m/v, 0.025 % m/v, and 0.005 % m/v

Microspectrophotometry Measurements:

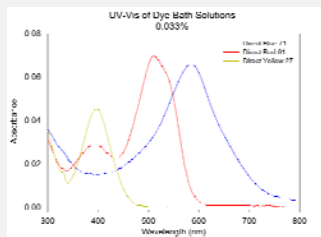
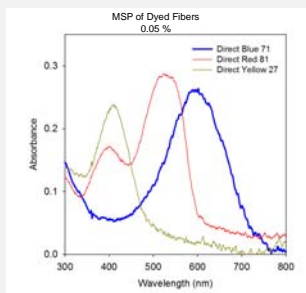
- Absorbance spectra of single fibers mounted in glycerol on quartz were obtained using a MSP 121 microspectrophotometer from CRAIC Technologies.
- Analysis was repeated at specified intervals.



Comparison of Dyes and Dyed Fibers

Dyes

- A portion of each dyebath solution was analyzed using UV/Vis spectroscopy.
- Allows for comparison of spectra between the dye solution and the dyed fiber.



- The overall shape and position of absorbance peaks was found to be similar for each dye.
- Some slight differences, especially between the yellow and red dye around 400 nm.
- Overall, absorbance was lower, as expected since MSP is a microanalysis technique.

Photobleaching

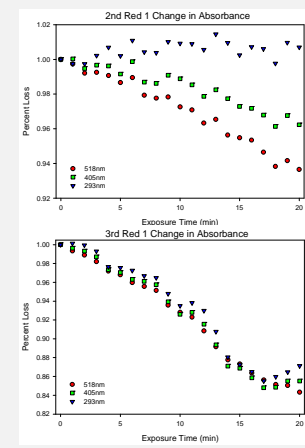
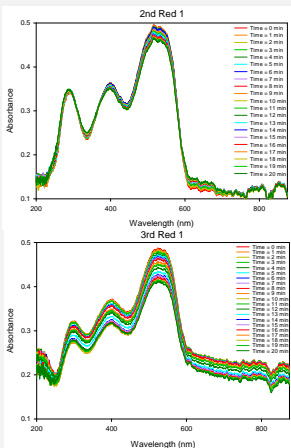
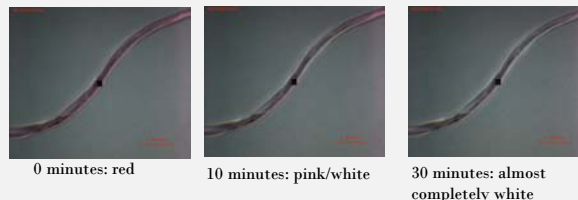
- MSP generally expected to be a nondestructive evaluation method.
- High intensity UV light sources can cause a reduction in the intensity of absorption during analysis, a phenomenon typically referred to as photobleaching.
- Historically, dye chemists have been concerned with lightfastness of dyed fabrics.
- Fading of dyed fabrics after exposure to sunlight is well-known and related, but the lamps used in the MSP cause fading to occur rapidly.
- A recent review article found that approximately half of the scientific papers on spectroscopic analysis of textile fibers focused on UV-Vis MSP, but photobleaching was only mentioned in a few papers from Was-Gubala and Starczak.

Dyed fabric showing poor lightfastness.



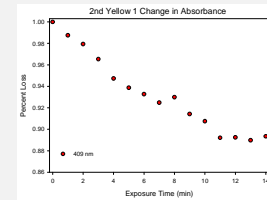
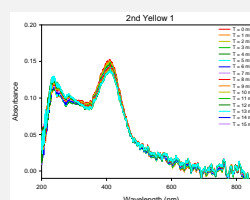
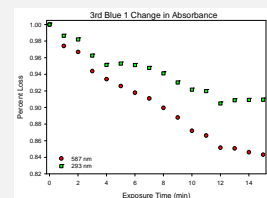
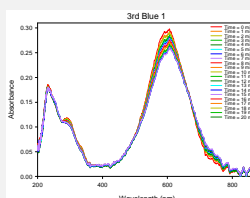
<http://crystalball.blogspot.com/2010/05/patio-furniture-rough-dyeing.html>

Observation of Photobleaching- Red Dye



- Poor repeatability between changes in absorbance in dyed fibers.
 - Due to nonuniform dye uptake- common in natural fibers.

Observation of Photobleaching- Blue and Yellow Dyes



- Similar trends were observed for the fibers dyed with blue and yellow dyes in the highest concentration.
- Repeatability still an issue due to nonuniform dye uptake.
- Lower concentrations of yellow (not shown) did not demonstrate much of an effect, possibly since there was so little dye on the fiber at time zero.
- Photobleaching can be minimized by using a glass slide or UV filter (results not shown here) to protect the fiber while setting up a measurement.

Conclusions and Future Work

- Photobleaching is readily observed on cotton fibers dyed with red, yellow, and blue direct dyes, and forensic scientists should be aware of this phenomenon.
- Photobleaching can be minimized by careful control of measurements on susceptible fibers (reduction in time of exposure, careful use of shutters, etc.)
- Additional measurements will be made to better quantify repeatability.
- Recommendations for exposure time and filtering procedures will be developed.