

Introduction

- Current state-of-the-art protocols to synthesize complex organic compounds suffer from low reaction yields, low selectivity, the use of reagents, and harsh reaction conditions.
- Photocatalysts use light to drive organic reactions and have been shown as an effective way to improve reaction yield and selectivity. However, the recycle and reuse of most traditional photocatalyst can be challenging and expensive.
- Textiles can be used as substrates to anchor photocatalysts to enhance their recovery and recyclability in the synthesis of complex organic compounds, which would make the process greener and more sustainable.
- Sulfide oxidation is an important reaction in many pharmaceutical drugs and is a model reaction to test the catalytic performance of our textile-bound photocatalysts.

Objective

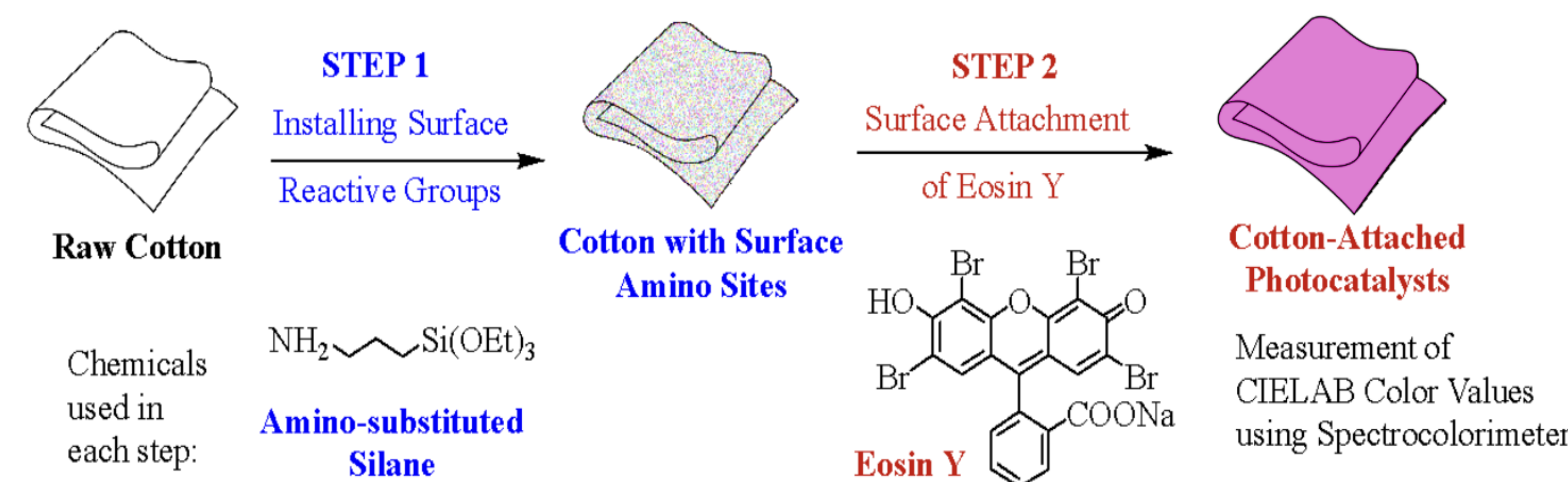
The central goal of this work was to develop textile-bound photocatalysts by covalently attaching molecular photocatalysts to the surface of cotton. We then aimed to synthesize sulfoxides through the oxidation of sulfides, using textile-bound photocatalysts. This reaction can either create sulfoxide or sulfone; sulfone is not desired and ends up as organic waste. Our objective is to assess the effect of color of our photocatalysts on the reaction yield (catalytic performance) of the sulfide oxidation reaction.

Materials and Instruments

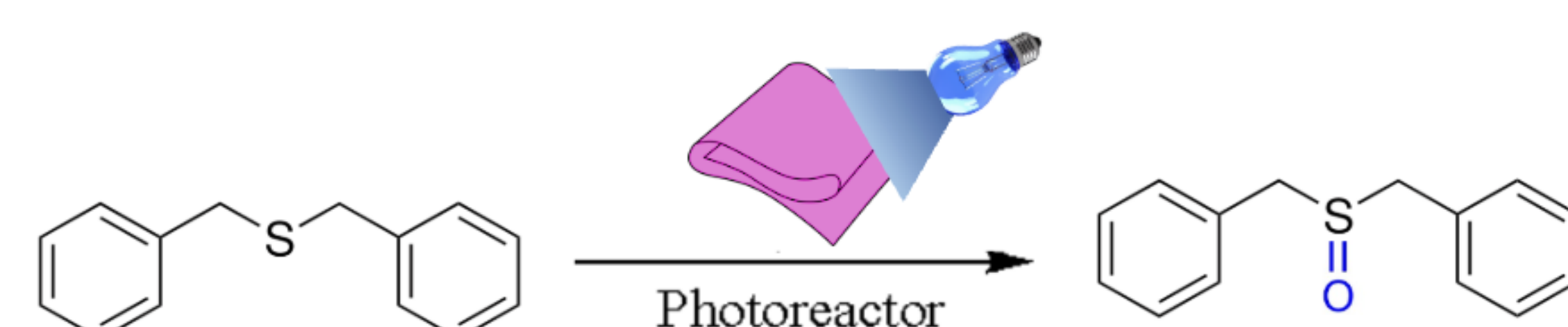
- Cotton fabric was obtained from the Apparel Merchandising and Management Department, Cal Poly Pomona and pre-treated by boiling in alkaline solution for 90 minutes prior to attachment with APTES.
- Sodium acetate (Aldrich Chemical Company, 99+%), Sodium hydroxide (Fisher Chemical, 97%), Acetic acid (Fisher chemical, >99.7%), Ethanol (Thermo Scientific, 99.5+%), (3-aminopropyl)triethoxysilane (APTES) (Sigma Aldrich, >98.0%), Eosin Y (Sigma Aldrich), DCC (Sigma Aldrich), Acetone (Fisher Chemical, 99.5%), DMSO (EMD, 99.8%)
- DI water was used to make all solutions
- Color measurement was performed utilizing Ci62 Handheld Spectrophotometer.
- Photoreactions were performed using Hepatochem photoreactor with a 450nm LED lamp.

Results and Discussion

Phase 1: Synthesis and Color Measurement of Cotton-Attached Photocatalysts



Phase 2: Measurement of Dibenzyl Sulfide to Dibenzyl Sulfoxide



Photocatalyst Dyeing Procedure: Pre-treated cotton fabric was submerged in a solution containing the photocatalyst **Eosin Y** to immobilize the dye onto the textile surface. The fabric was allowed to soak to promote dye adsorption and binding to the cotton fibers. After dyeing, the fabric was rinsed and washed several times to remove excess or loosely bound dye. Even after multiple washes, the dye did not fully leach from the cotton fabric, indicating strong attachment of the photocatalyst to the textile surface.

Colorimetry:

- This technique measures color numerically; the **L*** value indicates lightness (lower = darker, higher = lighter).
 - The control fabric showed the highest L* value (69.73), indicating the lightest color. This confirms that APTES enables higher photocatalyst loading, likely, through a covalent bond.
 - Some variation was observed between samples, reflected in the standard deviation of 3.660. This variation suggests differences in photocatalyst loading between fabric samples, which is consistent with the slight shade variations observed visually.
- Overall, the colorimetry data supports that Eosin Y was successfully immobilized onto the cotton fabric and provides quantitative evidence of differences in photocatalyst loading between samples.

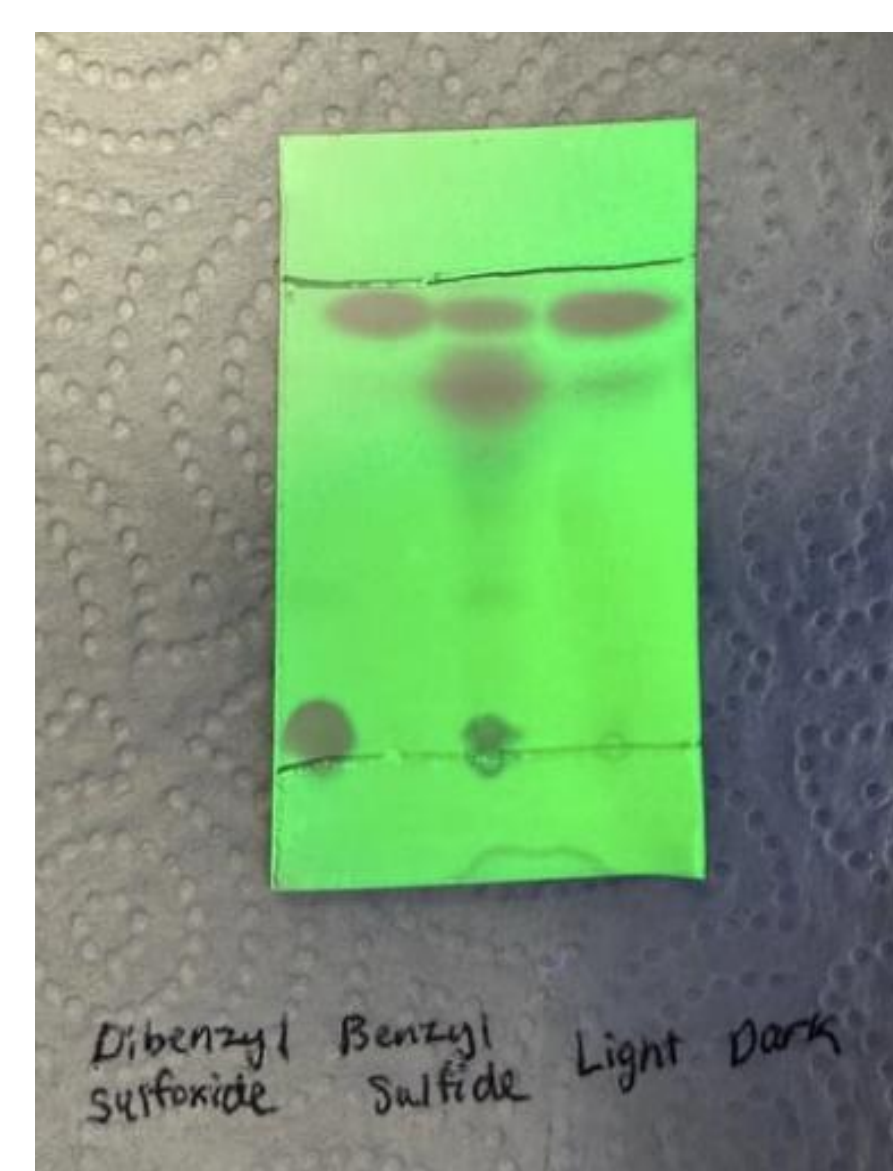


Figure 2. TLC results indicating formation of sulfoxide under light exposure with Eosin Y-treated cotton fabric.

Cotton Fabric Standard Deviation		
Samples	L* Values (Mean)	St Dev.
Control	69.73	0.2186
1	57.43	0.5887
2	60.99	1.343
3	64.75	0.5510
Total	61.06	3.660

Thin Layer Chromatography: TLC analysis was used to evaluate the photocatalytic activity of the textile-bound photocatalyst by monitoring the oxidation of sulfide to sulfoxide. Reaction mixtures were analyzed on TLC plates to compare the migration of reactant and product, allowing visualization of reaction progress. Results showed sulfoxide formation only when photocatalyst is present in the reaction and blue light illumination.



Figure 1. Cotton fabric dyed with the photocatalyst Eosin Y, showing the characteristic pink coloration after immobilization.

CIELAB Colour Space

L = Lightness 0 to 100
a = -100(Green) to +100(Red)
b = -100(Blue) to +100(Yellow)

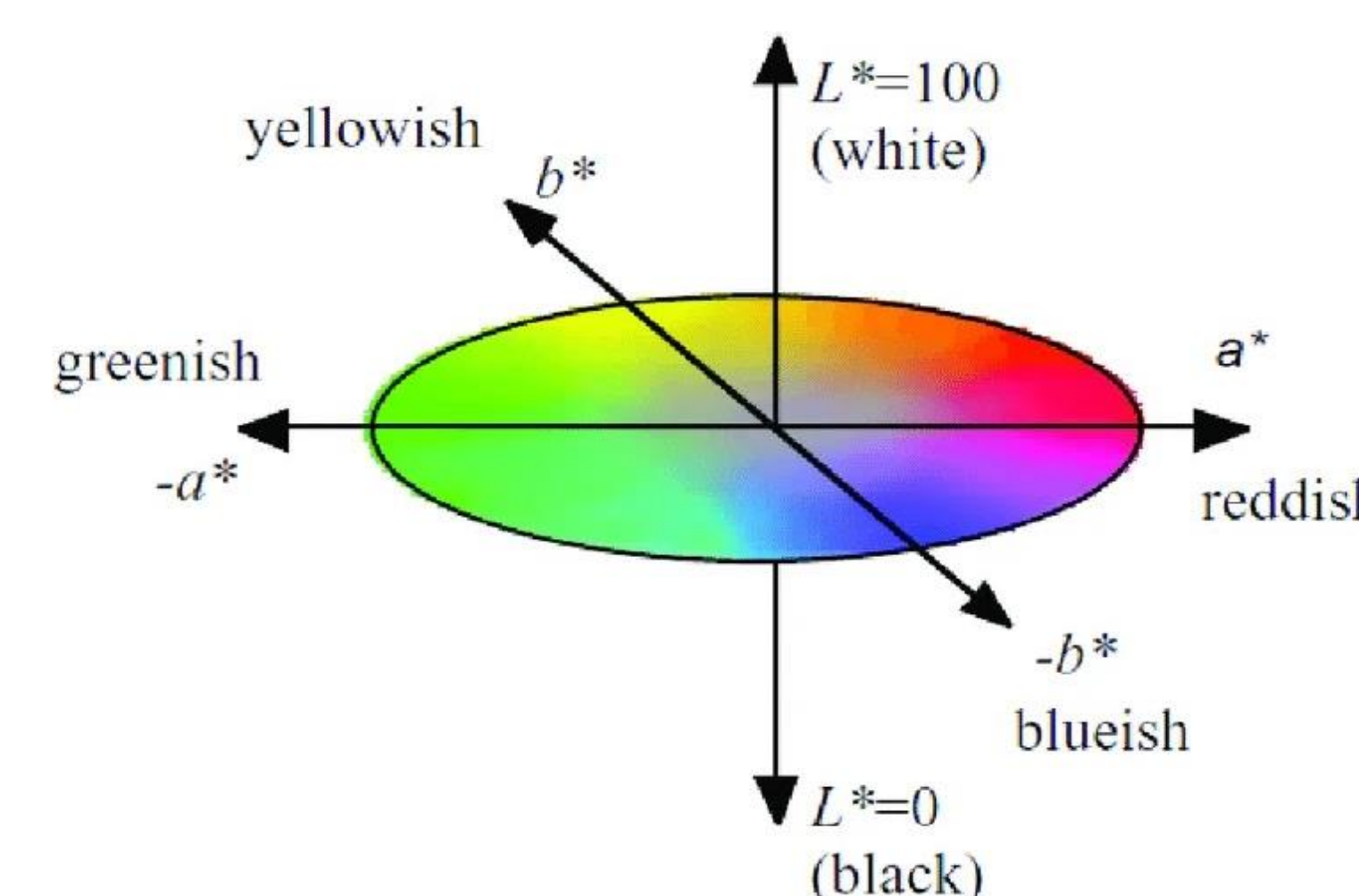


Table 1. Differences in L* values confirm darker coloration in treated samples, while variation in standard deviation reflects differences in photocatalyst loading among fabric samples.

Summary and Conclusions

The photocatalyst, Eosin Y, was bound to cotton that was functionalized by APTES. The dye samples were washed with acetone, ethanol, and water to remove any excess photocatalyst.

-**Eosin Y** was successfully immobilized onto pre-treated cotton fabric, indicated by the bright pink coloration of the materials.

- **Cotton fabric** samples showed slight shade variations, likely due to challenges in controlling the amount of DCC during the immobilization process.

-**TLC analysis** of light-driven oxidation of sulfide confirms formation of sulfoxide only when the photocatalyst and light are used.

Future Work

Herein, this work focused on the synthesis of cotton-attached Eosin Y photocatalysts. Future studies will focus on:

- Development of highly reproducible optimized protocols for photocatalyst dyeing
- Quantitative determination of sulfoxide formation using NMR analysis.
- Assessing the relationship between photocatalyst color and catalytic performance.

References

Caminos, D. A.; Rimondino, G. N.; Gatica, E.; Massad, W. A.; Argüello, J. E. Riboflavin and Eosin Y Supported on Chromatographic Silica Gel as Heterogeneous Photocatalysts. *ACS Omega* 2023, 8, 30705–30715.

Acknowledgments

The Bhide research group for their contributions and support. We would like to acknowledge the Cal Poly Pomona Foundation and Dr. Jiangning Che from the Apparel Merchandising and Management Department, Cal Poly Pomona.

