QUANTITATIVE STUDIES IN PHOTOSTABILITY OF DYES AND FIBRES

by

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PUBLICATIONS

The work described in this thesis has been included in the following papers.

1. Papers already published:

(i) A Study of Light Damage to Undyed Textile Yarns under a Fading Lamp at a Fixed Humidity.
C.D. Shah and R. Srinivasan,
J. Text. Inst., 66, 249 (1975).

(ii) Lightfastness of Disperse Reactive Dyes on Drawn and Undrawn Nylons.
C.D. Shah and R. Srinivasan,
Text. Res. J., 45, 486 (1975).

(iii) Studies of Light Fading of Reactive Dyes on Cellophane.
C.D. Shah and R. Srinivasan,
J. Appl. Chem. Biotechnol., 25, 615 (1975).

(iv) Activation Energies of Light Fading of Dyes in Polymers.
C.D. Shah and R. Srinivasan,
Text. Res. J., 46, 380 (1976).

(v) Some Quantitative Studies on Light Fading of After-treated Direct Dyes.
C.D. Shah, R. Srinivasan and J.V. Murthy,
J. Appl. Chem. Biotechnol., 25, 809 (1975).

2. <u>Papers accepted for publication</u>:

(vi) Photostability of Water-assisted Solvent-dyed Direct and Reactive Dyes on Cellophane.
C.D. Shah and R. Srinivasan,
Text. Res. J., <u>46</u> (1976).

3. <u>Papers already submitted to journals for publication</u>:

(vii) Effect of Humidity on Phototendering of Undyed Fibres.
C.D. Shah and R. Srinivasan.

(viii) Mechanism of Light Fading of Dyes on Cellophane and Poly(ethylene terephthalate).
C.D. Shah and R. Srinivasan.

(ix) Photodegradation of Poly(ethylene terephthalate) in the presence of Disperse Dyes.
C.D. Shah and R. Srinivasan.

(x) Quantum Efficiency of Fading of Disperse Dyes in Textile Substrates.
C.D. Shah and R. Srinivasan.

4. <u>Papers in preparation</u>:

(xi) Effect of Resin Finishing on Lightfastness of Azoic Dyes on Cellophane.
C.D. Shah and R. Srinivasan.

(xii) Light Fading of Disperse Reactive Dyes on Nylon.
C.D. Shah and R. Srinivasan.

ABSTRACT

The thesis describes a variety of types of experiments designed to elucidate some physical and chemical factors which influence photostability of dyes on textile fibres and also of undyed textiles. Also it deals with some technical aspects of lightfastness.

The subject matter is divided into the following parts and sections:

PART I Effect of Light on Undyed Textile Fibres.

Section 1. Light Damage to Undyed Textile Yarns under a Fading Lamp at a Fixed Humidity

By intensive testing it was found that Light Fastness Tester can be used for light damage assessments of a variety of undyed textile fibres. It gives results in agreement with those obtained by exposure to daylight in regard to percentage loss in tensile strength, elongation and energy to break.

Section 2. Effect of Humidity on Phototendering of Undyed Fibres

A variety of undyed textile fibres exposed to Light Fastness Tester under different humidity conditions are found to degrade to different degrees as regards percentage loss in tensile strength, Cotton, viscose, poly(vinyl alcohol) and nylon are found to be very sensitive to changes in humidity

whereas Terylene and Orlon are the least sensitive. Further confirmation is obtained about the enhanced photochemical degradation of undyed textile fibres due to the presence of foreign bodies like titanium dioxide.

PART II Influence of Physical Factors on Photostability of Dyes.

Section 1. Lightfastness of Disperse Reactive Dyes on Drawn and Undrawn Nylons

Assessment of lightfastness on Fade-Ometer of disperse reactive dyes on drawn and undrawn nylons reveals that the dyes on drawn nylons are probably in a state of very low aggregation, and the higher lightfastness obtained can be due to the "diffusion-restriction" effect.

Fixed dyeings are not found to be faster than unfixed ones, tending to show that the dye-fibre bond probably does not contribute to higher lightfastness.

Section 2. Photostability of Water-assisted Solved-dyed Direct and Reactive Dyes on Cellophane

Absorption spectra of direct and reactive dyes in aqueous solution, solvents mixture and water-assisted solvent-dyed Cellophane were examined to study the changes in hue if any, values of y/x band ratio were examined to study the physical state of the dyes in the various media, and characteristic fading curves were examined for comparative studies of lightfastness of dyes applied on Cellophane by the conventional method from aqueous medium and by the methods of solvent dyeing tried in the present investigation.

Pre-swelling with aqueous solution of sodium carbonate is found to give satisfactory reactive dyeings. Thus a new technique of solvent dyeing of reactive dyes is evolved.

Lightfastness of both direct and reactive dyeings produced by solvent dyeing methods tried herein is found to be the same as that of the conventional aqueous dyeings.

PART III Quantitative Studies of Chemical Reactions in Light Fading of Dyes.

Section 1. Light Fading of Reactive Dyes on Cellophane.

It is found that aggregation of reactive dyes in aqueous solution is greater than that on Cellophane film. Urea is found to cause disaggregation of these dyes in both phases. The state of aggregation of reactive dyes on Cellophane is found to be intermediate between that of disperse dyes on polyester and that of disperse dyes on acetate and cellulose triacetate. The particle size distribution of the dye in the fibre changes on addition of the urea, i.e., particles of a more uniform size are obtained.

Section 2. Light Fading of Disperse Reactive Dyes on Nylon

It is found that in disperse reactive dyes from acetone solution to their fixed or unfixed state on nylon, there is no change in hue.

Aggregation of disperse reactive dyes on nylon is found to be higher than that obtained in acetone solution. Fixed dyes on nylon show greater aggregation than unfixed ones.

y/x ratio on fading shows that these dyes aggregate on nylon. Dye-fibre bond does not seem to play a role in improving the lightfastness.

Fading at 53 ± 1°C of disperse reactive dyes on nylon, and of disperse dyes on polyester is found to be comparatively insensitive to changes in relative humidity; but the disperse dyes on nylon are found to be very sensitive. Like disperse dyes on polyester, fading of disperse reactive dyes on nylon is found to accelerate at high temperature under all different conditions of humidity.

Section 3. Activation Energies of Light Fading of Dyes in Textile Substrates

Activation energies of fading of acid dyes on gelatin film, reactive dyes on Cellophane, and disperse reactive dyes on nylon film were determined. This has given further evidence that the values of activation energy of fading of dyes on fibres depend on the nature of the substrate and the class of the dye.

The values are found to decrease with loosening of the structure of the fibre; wool as for example gives low values.

Fading of dyes on wool seems to be almost insensitive to wide variations in humidity.

The values of disperse dyes and disperse reactive dyes on nylon are found to be about the same. This tends to show that the reactive type of dye-fibre bond is not effective in lightfastness.

Section 4. Mechanism of Light Fading of Dyes on Cellophane and Poly(ethylene terephthalate)

Studies of relative rates of fading of dyes and Hammett σ-value of substituents in their molecules lead to a further evidence that fading of azo dyes on Cellophane and polyester is probably an oxidation type of reaction.

Section 5. Effect of Resin Finishing on Lightfastness of Azoic Dyes on Cellophane

Studies on the light fading of azoic-dyed Cellophane before and after application of crease-resist finishes have shown that the effect of presence of these resins on lightfastness is extremely small. This is found to be very much unlike the effect in direct and reactive dyeings, where the decrease in lightfastness is considerable.

Section 6. Photodegradation of Poly(ethylene terephthalate) in the presence of Disperse Dyes

It is found that fading of C.I. Disperse Yellow 5 on PET tenders the fibre. This is evident from the studies of changes in both physical and chemical properties like tensile strength, elongation, degree of polymerisation, carboxylic end group analysis etc.

Section 7. Quantum Efficiency of Fading of Disperse Dyes in Textile Substrates

Further evidence is obtained that quantum efficiency values for photolysis of disperse dyes on hydrophobic substrates are very low at all wavelengths, and they decrease with increase in wavelength of illumination. The values are found to be in the range 10^{-4} to 10^{-6}.

PART IV Technical Aspects of Lightfastness of Dyes

Section 1. Quantitative Studies on Light Fading of After-treated Direct Dyes

Quantitative measurements of increase in lightfastness of direct dyes on Cellophane on after-treatment with different metallic salts, e.g., sulphates of copper, cobalt, nickel, chromium and (ferrous) iron were carried out.

Copper sulphate is found to be the best of all these salts. It is found to give higher aggregation of the dye in the fibre. The metal complex formation with dye structures of the type o-hydroxy-o'-methoxy (or o'-hydroxy or ethoxy) azo are found to be more useful for copper after-treatment than the dyes with Salicylic acid residue.

Section 2. Improving Lightfastness Properties of Azoic Dyes on Cotton Fabrics

Shades produced by conventional method of azoic dyeing on bleached cotton fabrics and also by the method of pigment dyeing of the same azo pigments are found to be comparable. The lightfastness of the pigment dyeings is found to be higher than that of the azoic dyeings at all concentrations of the dye in the material.

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