Lightfastness of Reactive Dyes on Cellophane Dyed from Aqueous and Non-Aqueous Mediums

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An attempt has been made to study the state and lightfastness of three reactive dyes on normal cellophane and cellophane treated with sodium zincate solution, the dyeing being carried out by using water, water-acetone, formamide-acetone and DMSO-acetone mediums. All the three dyes were found to be present in the aggregated form on both the films. The extent of aggregation as measured from $\frac{\alpha}{\beta}$ ratio of the spectra of dyes was found to be in the order: water > water-acetone > formamide-acetone > DMSO-acetone. The lightfastness of dyes as indicated by characteristic fading curves also followed the above order. The dyeings on cellophane treated with sodium zincate showed higher lightfastness, which was attributed to better dye penetration due to the elimination of skin structure.

The lightfastness of different classes of dyes on textile materials and their mechanisms have been reviewed by several workers. It has been suggested by many workers that the stronger the bond formed between the dye and the fibre, the greater the lightfastness of the dyeing. This has been attributed to the transfer of excitation energy from the dye molecule to the macromolecule of the fibre. However, the reactive dyes have the firmest dye-fibre bond, and their lightfastness gradings are not higher than those of other fast dyes on cellulose.

Krichevskii and Vachobov found, from the rate of fading of adsorbed and covalently bonded reactive dyeings on cellulose, that the nature of dye-substrate bond does not materially affect the lightfastness of reactive dyes.

Giles and coworkers emphasized that lightfastness in a hydrophilic substrate is largely governed by the physical form of the dye and that dyes of high lightfastness are likely to be more highly aggregated than those of low lightfastness. This finding has been confirmed by Weissbein and Cohen from electron micrograph studies.

Hildebrand and Pisarvskanya et al. also observed that not only the physical form but the chemical structure of the basic chromophore is also important in fading rate.

Kissa observed that electrolytes and dyeing methods affect the lightfastness of reactive dyes, lightfastness being higher for the process which favoured dye penetration. AATCC Delaware Valley section and Silver reported no change in the lightfastness of direct and reactive dyes when the dyeings were carried out using compatible mixtures of solvent or water-solvent emulsion systems. Bose noted a slightly inferior lightfastness of reactive dyes on cotton dyed using dimethylformamide-trichloroethylene solvent mixtures. In our earlier paper the low dye uptake of viscose rayon as compared to cotton when the dyeings were carried out using water-acetone mixture was attributed to the presence of highly oriented skin structure in viscose rayon which offers resistance to dye penetration. Treatment of viscose rayon with sodium zincate suitably modified the skin structure and increased the dye uptake and dye fixation equivalent to that on cotton. In the present paper, an attempt has been made to study the state and the lightfastness of three reactive dyes on cellophane as well as treated cellophane (sodium zincate 15% v/v) dyed with reactive dyes using water, water-acetone, formamide-acetone and DMSO-acetone mediums.

**Materials and Methods**

Three reactive dyes, viz. C.I. Reactive Red 31 (Procion Red H 8B), Orange 13 (Procion Orange H 2R) and Blue 5 (Procion Blue HGR), were used after purification by the solvent-nonsolvent method. The cellophane film (25 $\mu$m thick) was boiled for half an hour with 1 g/litre Lissapol N, washed free from the detergent and dried at room temperature.

Sodium zincate solution was prepared by the standard method. The cellophane film was pretreated with sodium zincate (15%, v/v) at room temperature for 15 min. The film was washed and air-dried.

Fading experiments were carried out on a lightfastness tester by using 500 W mercury-tungsten fluorescent lamp (MBTF). The absorption spectra
confirmed from the fading rate curves of C.I. Reactive Red 31 and Orange 13 on cellophane (Figs 5 and 6), which showed that the initial fading rate was higher, the fading proceeding later at a steady-rate, which implied that the initial fading was due to the fading of

Results and Discussion

The absorption spectra of three dyes on cellophane (treated and untreated) dyed using water, water-acetone, formamide-acetone and DMSO-acetone were the same on both the films. Typical absorption spectra of three reactive dyes on treated cellophane are shown in Figs 1-3. All the dyes gave two peaks. The band at higher wavelength, called as \( \lambda_1 \), was attributed to the monomeric form of the dye, whereas the shorter wavelength band \( \lambda_2 \) was attributed to the aggregated form. The extent of dye aggregation, expressed as \( \lambda_2/\lambda_1 \) ratio, was different when the dyeings were carried out using different mediums. The aggregation tendency was in the following order: water > water-acetone > formamide-acetone > DMSO-acetone. Dye aggregation to a lesser extent on the film dyed from solvent-acetone medium was attributed to the disaggregation of the dyes in solution.

Rate of fading curve—Fig. 4 shows that the fading at \( \lambda_1 \) band is faster than at \( \lambda_2 \) band. A similar trend was observed for other dyes in all the mediums used for dyeing. Thus, the \( \lambda_2/\lambda_1 \) ratio increased with the time of fading. This increase can be attributed to the increase in the average aggregation number. This was also

confirmed from the fading rate curves of C.I. Reactive Red 31 and Orange 13 on cellophane (Figs 5 and 6), which showed that the initial fading rate was higher, the fading proceeding later at a steady-rate, which implied that the initial fading was due to the fading of

of unexposed as well as exposed films were scanned with a Beckmann DK2A spectrophotometer.
Films were pre-swollen with aqueous Na\(_2\)CO\(_3\) solution (10-50 g/litre) and centrifuged before dyeing. Dyeing was carried out in a Beaker dyeing machine (liquor ratio 100:1). Dye-bath exhaustion was carried out at 25°C for 1 hr and fixation at 60°C for 1 hr. The dyed samples were soaped at boil, thoroughly washed and dried at room temperature. The aqueous dyeing experiments were carried out at 80°C using NaCl (60 g/litre) and Na\(_2\)CO\(_3\) (10 g/litre).
the monomeric dye form followed by slow fading of
the aggregated dye, whereas Reactive Blue 5
showed initially negative fading, i.e. the intensity of
the colour actually increased with time (Fig. 7). This
trend appears to be due to the physical breakdown of
the absorbed dye aggregates by the heat of
illumination7.

Characteristic fading curves—The characteristic
curves revealed that the time required for 10% fading on treated cellophane was
higher than on normal cellophane at any particular
initial optical density, showing better fastness on the
former substrate (typical example is shown in Fig.8).
This may be attributed to the better penetration of dye
in the former substrate, indicating the elimination of
highly oriented skin structure which offers resistance
to dye penetration. The details of sodium zincate
treatment and the modification of the skin structure
are described in an earlier paper25. The films dyed
from aqueous medium showed higher lightfastness.
This may be attributed to less dye aggregation both in
solution and on substrate when dyeings were carried
out using a non-aqueous medium. Among the three
dyes, Blue 5 showed very good lightfastness, which
may be due to the anthraquinone structure of the dye
as suggested by the earlier workers18,19,31.

Fig. 4—Change in y/x ratio with time of fading on cellophane film
dyed in aqueous medium (dye: Blue 5)

Fig. 5—Fading rate curves of cellophane dyed with Red 31 in
aqueous medium

Fig. 6—Fading rate curves of cellophane dyed with Orange 13 in
aqueous medium

Fig. 7—Fading rate curves of cellophane dyed with Blue 5 in
aqueous medium
Fig. 8—Characteristic fading curves of Blue 5 on treated and untreated cellophane dyed in different mediums [(○—○—○) water; (△—△—△) water-acetone; (□—□—□) formamide-acetone; and (×—×—×) DMSO-acetone]

Conclusion

When the dyeing was carried out using water, water-acetone, formamide-acetone and DMSO-acetone mediums, the three reactive dyes on cellophane were present in the aggregated form as indicated by y/x ratio. The extent of dye aggregation was in the order: water > water-acetone > formamide-acetone > DMSO-acetone. Higher lightfastness obtained on sodium zinate-treated cellophane is attributed to the better dye penetration due, in turn, to the elimination of highly oriented skin structure.

References

22. AATCC Delaware Valley Section, Text Chem Color, 5 (1973) 60-49.