

Effect of Reactive Dyes Structure on Light Fastness

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Abstract- Reactive dyes are preferred dyes in apparel processing industry due to ease of application and wide shade range and excellent wet fastness properties. Reactive dyes are classified based on chromophore type, reactive group and solubilizing (sodium salt of sulphonic or carboxylic acid) group. Cotton fabric dyed with the different reactive dyes and effect of dyes chemistry on fastness is analyzed. It is observed that reactive dye light fastness mainly depends on chromophore. The azo chromophore has lower light fastness. Metal complex and anthroquinon chromophore dyes has good light fastness. Sulphonic acid group in reactive dye is only for improving solubility of dye and not have impact on light fastness.

Key word- Reactive dyes; Light fastness; chemical structure; covalent bond; cotton fabric.

I. INTRODUCTION

Reactive dyes attach to the cellulose fiber by forming a strong covalent (molecular) chemical bond. These dyes were developed in the 1950's as an economical process for achieving acceptable colorfastness in cellulosic fibers. Bright shades and excellent wash fastness properties are the trademark of reactive dyes. Reactive dyes have water solubility and can possess various reactive groups which during the process of dyeing react chemically with the fibre substrate to form a co-valent bond in presence of alkali so that it becomes a part of the fibre itself.

There are many types of reactive dyes with different reactive groups, ie with different reactive systems, that react with substrate to form covalent bonds. The chromophore of their molecules are very similar ie either azo, anthroquinone, phthalocyanine chromophore or others. The general formula for reactive dye structure are as follows
S-F-T-X

Where S: Solubilizing group, F: Chromophore, T: Bridging group, X: Reactive system

The dye structures consist of two parts (16); the chromogen and the reactive system, and it is convenient to discuss them separately. Since difference ranges usually have similar chromogen, and only differ in reactive system. Effect of this change in chemical structure on light fastness is analyzed in this paper. Light induced photo fading of

dyed system is a complex process and among many factors, the chemical structure of the dyes plays an important role. Egeerton and Morgan[1] stated that the structure of the chromophore of the dye was the major influencing factor and the position of substituents also significantly influenced the light fastness results. Different light stabilities can be achieved with dyes of the same chromophore carrying different substituents. The phenols and their sulphonated or carboxy derivatives as well as certain aminonaphthol - sulphonates improve the light stability of the dyed system. However anilines, naphthols, naphthlamines, and certain amino-naphthols have a negative influence on light fastness [2].

Meuly [3] studied about dyed system observed that sulfonic acid substituents on the coupling component decreased the light stability, but that similar substitution, in the diazo component, however, increased the light stability. The light stability decreasing effect of -OH, -NH₂, and -NHR groups in the azo dye molecule was observed by Blumberger[4]. Acetylation or benzooylation of these groups improved the light stability, whereas methylation of -OH groups acted in the opposite way. From a more generalized viewpoint, the light stability of azo dyes was improved by electron accepting substituents and deteriorated by electron donating ones. However, the presence of too many electron accepting groups in an azo dye may cause a drastic drop in the light stability[5].

Substituents in the dye molecule which enhanced the reduction of the dye chromophore accelerated photofading in the case of reductive mechanism, and the substituents acting in the opposite way caused a lowering of photofading. This observation has been noted for substituents helping or preventing oxidative reactions in the case of an oxidative photofading mechanism [6]. The electron donor or acceptor nature of the substituents influenced the light fastness, but these parameters can be changed in the photo excited state of the dyes [7]. Hladic and Svec[8] showed that the role of the chromophore was predominant in establishing light stability. Azo groups connected to a naphthyl residue in the dye chromophore usually resulted in a dye having poor light stability. The objective of the present work is to evaluate the effect of reactive groups vinyl sulphone, monochlorotriazinyl and Vinyl sulphone and Monoflorotriazinyl & vinyl sulphone dyes on fastness.

Experiment Details

Materials

Fabric

Plain woven scoured, bleached and mercerized cotton fabric

| | |
|-----------------|----------------------|
| Yarn density | |
| warp | 288/10 cm |
| weft | 255/10 cm |
| Surface density | 108 g/m ² |
| Yarn fineness | |
| warp | 20 tex |
| weft | 20 tex |
| Whiteness Index | 65.0 CIE |
| Absorbency | 3 S |

Dyes

The dyes taken for the study were, obtained from commercial sources and shown in table1 without any purification to simulate industry condition.

Methods

Dyeing

Dyeing of the scoured fabrics was performed at 60°C using recipe shown in Table 1. Exhaustion of dyes carried with sodium sulphate for 30 min and fixation with soda ash for 45 min. After dyeing, the samples were rinsed in distilled water, soap solutions, rinsed again in distilled water and then dried.

Fastness Testing

The dyed samples were tested according to ISO standard methods. The ISO 105 C02 colour fastness to washing, ISO 105-X12 colour fastness to rubbing and ISO 105 B02 Colour fastness to light were used. The dyed fabric was exposed separately for 36h [at 40°C under artificial light source (day light B01, James H. Heal and company, Hamifax, England), equipped with xenon arc and mercury- tungsten florescent, whose wave length was similar to that of sunlight. The change was compared with original specimen and assessed by Data color CIE Lab dE value.

A. RESULTS AND DISCUSSION

Effect of reactive group on Light fastness

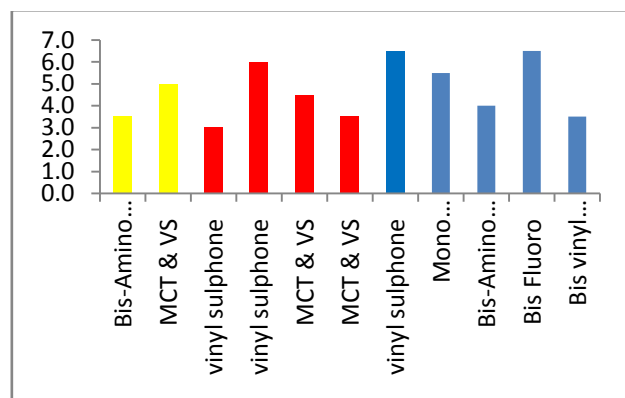


Figure 7.1 Effect of reactive group on light fastness

Strong covalent bond between the dye and fibre seems to facilitate the transfer of energy from the excited dye molecule to the fibre resulting in increased stability of the reactive dyes (14). The first two samples are yellow colour, four samples from red colour and last five is blue colour. Reactive yellow 176, Reactive red 194 and reactive red 195 constructed with monochloro triazine and vinyl sulphone reactive group, but the light fastness for all three is differ from each other. In red colour of first two dyed samples has vinyl sulphone reactive group reactive red 22 has poor light fastness and reactive red 23 has higher light fastness. Reactive red 194 and 195 also has monochloro triazine reactive group but the light fastness is not similar. In reactive blue 19 and 250 are vinyl sulphone reactive group but the light fastness is not similar. Reactive blue 19 and blue 160 has reactive group vinyl sulphone and mono chloro triazine respectively their light fastness is similar. Reactive blue 19 and reactive blue 204 has vinyl sulphone and bis floro reactive group, but the light fastness is equal. From the above figure it is very clear that the light fastness is not depending on reactive group the above result is stated by D Rastogi (15). Another one study by remi 1996 also help to confirm the above result. Reactive dyes with excellent light fastness have a common chromophore but different reactive groups(12). No significant effect of nature of reactive group on light fastness could be observed.

Effect of chromophore on light fastness

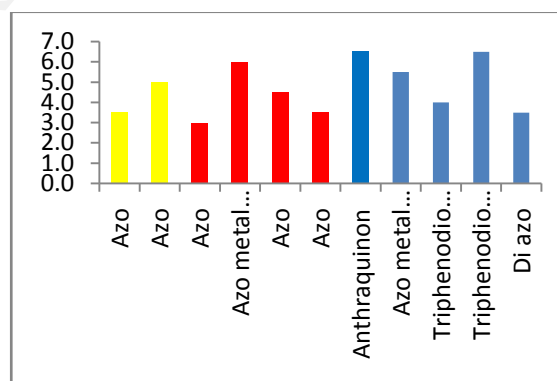


Figure 7.2 Effect of chromophore on light fastness

The light fastness in one to eight scale above five rating light fastness is the buyer requirement. In azo chromophore dyes Reactive yellow 135, yellow 176, reactive red 22, red 194, red 195 and reactive blue 250 has below 5.0 light fastness. In reactive blue 19 has anthraquinon chromophore is the reason for good light fastness. Reactive blue 160 has azo chromophore but the light fastness is improved by complex with metal. From the above analysis reactive dye light fastness depends on chromophore. The azo chromophore has lower light fastness. Metal complex and anthroquinon chromophore dyes has good light fastness. The same trend has also been studied by Allen (5).

If this bond promotes energy transfer, there is an increase in the lightfastness of that component from which the energy is derived. If this bond impedes energy transfer, the material lightfastness decreases; and finally, if the dye-

fiber bond does not affect at all the excitation energy transfer, it will play no part in the processes of fading of dyes and photodegradation of fiber.

Light induced photo fading of dyed system is a complex process and among many factors, the chemical structure of the dyes plays an important role. Egeerton & Morgan (1) stated that the structure of the chromophore of the dye was the major influencing factor and the position of substituents also significantly influenced the light fastness results. Different light stabilities can be achieved with dyes of the same chromophore carrying different substituents. The phenols and their sulphonated or carboxy derivatives as well as certain aminonaphthol - sulphonates improve the light stability of the dyed system. However anilines, naphthols, naphthlamines, and certain amino-naphthols have a negative influence on light fastness (2).

Effect of sulphonic acid group on light fastness

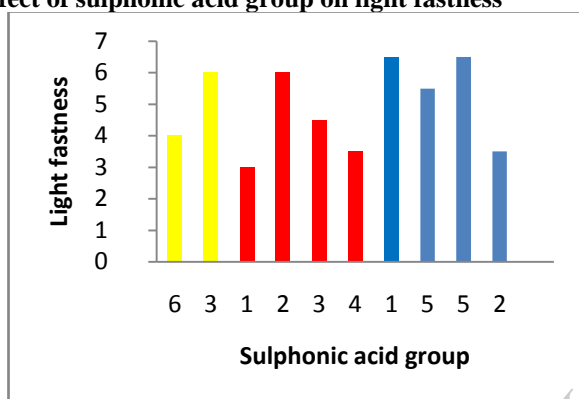


Figure 7.3 Effect of sulphonic acid group on light fastness

Reactive red 22, reactive red 23, reactive red 194 and reactive red 195 has respectively one, two, three and four sulphonic acid group is not shows any trend on light fastness. Reactive blue 19, blue 160, blue 204 and blue 250 has sulphonic acid group respectively. There is no trend observed in blue dyes by the change in number of sulphonic acid group. Sulphonic acid group in reactive dye is only for improving solubility of dye and not have impact on light fastness.

Light fastness based on depth of shade

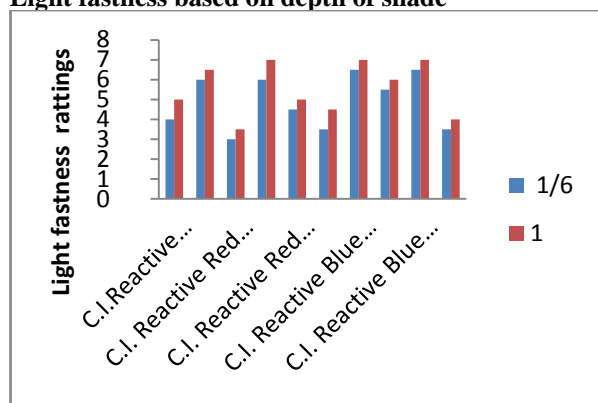


Figure 7.3 Effect of shade depth on light fastness

Increase in depth of the shade has positive effect on light fastness. All the tested dyes showed a minimum of 0.5 grade improvement in the light fastness rating compared to lower depth. C. I. Reactive yellow 135, Yellow 176 shows 1.0 to 0.5 grade, Reactive red 22, 194 and 195 shows 0.5 grade and Reactive red 23 shows 1.0 grade and all Reactive blue shows 1.0 grade increase in light fastness due to the standard depth increase from 1/6 to 1.0. Same dyes in lower depth have lower light fastness and in higher depth show the good fastness due to the fact that amount of dye molecules distraction is directly proportional to energy comes from light. Number of dye molecules distracted for a particular energy is same in all depth. But in lower depth number of the dye molecule is less than deeper depth, this causes reduction in light fastness for lower depth shades.

Light fastness is the dye concentration in the substrate. In the standards for the determination of dye light fastness, the effect of dye concentration is taken into account by determining it for three typical dye concentrations in the fiber. The increase of dye concentration promotes the possibility of transfer-excitation-energy transmission between adjacent molecules; i.e., the effect of concentrated self-extinction (11) is manifested more strongly the closer the distance between the molecules. The transfer of excitation energy is most easy between those dye molecules which are in direct constant contact. i.e., those which form aggregated dye particles. Naturally, the quantum efficiency of the dye fading is reduced by the transfer of the excitation energy.

Effect of Covalent bond on fastness

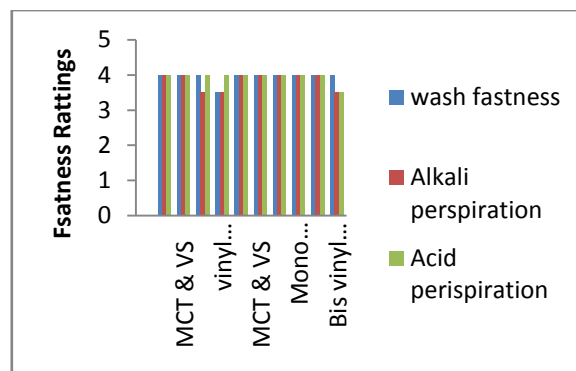


Figure 7.4 Effect of covalent bond on fastness

The figure 7.4 shows the effect of covalent bond on fastness. Covalent bond helps to transfer energy to fiber causes slight improvement in light stability. But the reactive group is not having any impact on light fastness (11). Wet fastness depend on reactive system. Vinyl sulphone(VS) is stable to acid and chloro triazine (CT) is stable for alkali and bi-functional contain MCT/VS or MFT/VS fast to both acid and alkali which helps to get good wet fastness.

CONCLUSION

Reactive dyes with excellent light fastness have a common chromophore but different reactive groups. No significant effect of nature of reactive group on light fastness could be observed. Reactive dye light fastness mainly depends on chromophore. The azo chromophore has

lower light fastness. Metal complex and anthroquinon chromophore dyes has good light fastness. Sulphonic acid group in reactive dye is only for improving solubility of dye and not have impact on light fastness.

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