CHAPTER 11
SUMMARY AND CONCLUSIONS

11.1 SUMMARY

The major objective of the present study is to investigate the factors and methods to improve the light fastness of reactive dyed cotton fabrics. The literature survey pertaining to light fastness reveals that a considerable amount of work has been carried out on light fastness of dyes. The visible light with oxygen and ultra violet exposure on the fabric are the major causes of light fading. The maximum work on light fastness is done with the testing environment and chemical structure of dyes. It is necessary to analyse the processes done from yarn to garment making. Any treatment given for improving light fastness should not degrade the other important fastness properties. So, it is mandatory to check the wash and rubbing fastness of the sample accurately.

The factors covered in this work are

- Yarn linear density on light fastness,
- Fabric structure on light fastness,
- Pretreatment method on light fastness,
- Dyeing method on light fastness,
- Dye chemical structure on light fastness,
- Effect of finish on light fastness,
11.2 CONCLUSIONS

With respect to the effect of yarn linear density on light fastness, the following conclusions are drawn.

i. Finer yarns show better light fastness than coarser yarn. In the indirect yarn count, finer yarn has thin diameter and coarser yarn has thick diameter. The reason may be the finer yarn is manufactured from the well matured fibres due to process of combing. The matured fibres have better half round cross section shape, which causes more reflectance of incident light energy.

ii. Another reason for good light fastness in finer yarn may be the fibre used for making finer yarn is well ripened and coarser yarn has immature and dead cotton fibres. The full ripened and mature fibre absorbs the dye and form covalent bond with hydroxyl group of cotton. The dead cotton fibre does not take dyes. Immature fibres takes limited amount of dye and the number of hydroxyl group in immature fibre is also less. This is also a cause for poor light fastness for coarser yarn.

With respect to effect of fabric structure on light fastness, the following conclusions are drawn.

i. The plain fabrics and single jersey fabrics have uniform surface structure. They give good light fastness compared with the wavy structured fabrics like pique and twill. The reason may be that the uniform surface shares energy equally and more reflection of the incident light taking place compared with the wavy rough surface fabric.
ii. The uniform surfaced plain and single jersey fabrics have good rubbing fastness than the twill and pique fabrics which causes better wet rubbing fastness.

The comparative analysis of pretreatment methods on light fastness leads us to the following conclusions.

i. There was no natural colour removal observed in grey boiling, enzymatic scouring and alkaline scouring. Semi bleaching shows the maximum whiteness due to the removal of the natural pigments in cotton. The cotton impurities are well cleared in alkaline scouring and semi bleaching.

ii. In terms of dry rubbing fastness, not much of variation is observed between the grey boiled, enzymatic scoured, alkaline scoured and semi bleached and dyed fabrics. But in the medium and dark shades, the grey boiled fabric shows comparatively lower wet rubbing fastness than other methods of pretreatment. The wash fastness of the grey boiled and dark shade dyed fabrics is comparatively lower than the fastness achieved through other methods of pretreated fabric.

iii. Good light fastness is not only based on dyes. The pretreatment process also contributes to some extent. Very good light fastness of pale shade is possible in semi bleaching and mercerised-semi bleached fabrics due to the removal of natural colour and good dye uptake.

iv. The reason for good light fastness of semi bleached fabric is due to the fact that the impurities in the fabrics are removed to the maximum extent.
v. In mercerised cotton, the bean shaped cross section of the fibre is converted into circular cross section, which helps to reflect more of light energy. Therefore mercerised fabric has improved fastness.

The comparative analysis of the dyeing methods on light fastness gives the following conclusions.

i. The exhaust dyeing and cold pad-batch dyeing have enough time for dye diffusion and better fixation. The diffusion and fixation time is insufficient in pad-humidity fix dyeing method.

ii. The colour strength of pad-humidity fix dyed fabric is 5-10% more than the cold pad-batch dyed fabric due to the surface dyeing.

iii. Lower wash fastness of pad-humidity fix dyed fabric compared with the exhaust and cold pad-batch dyed fabric is due to more surface colour.

iv. It has been concluded from this study that the exhaust and pad-batch dyeing of cotton fabric produces better light fastness than pad-humidity fix dyeing of fabric.

v. The pad-humidity fix process is suitable for light and medium shades to achieve good wash and rubbing fastness.

vi. Pad-humidity fix dyed fabric, light fastness is lower due to higher temperature with alkaline pH which reduces the stability of chromophore to the light.
vii. In order to get good light fastness of dyed material, care should be taken in selecting the dyes and dyeing method.

The comparative analysis of the dye chromophore type, reactive group and number of sulphanic acid group on light fastness gives the following conclusions.

i. Reactive dyes’ light fastness depends on the chromophore. The dyes with azo chromophore have lower light fastness. Metal complex and anthroquinone chromophore dyes have higher light fastness.

ii. 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.

iii. Sulphanic acid group in reactive dye is only for improving the solubility of dye and it has no impact on light fastness.

iv. Light fastness is dependent on the dye concentration in the substrate. Increase in the dye concentration promotes the possibility of transfer excitation-energy transmission between adjacent molecules.

The comparative analysis of the dye fixer based on formaldehyde, formaldehyde free, anionic, non-ionic and silicone softeners on light fastness gives the following conclusions. The analysis of contribution factor of process route on light fastness gives the following conclusions.

i. All finishing treatments cause shade change, but in case of formaldehyde free fixing, non-ionic and anionic softener treated samples show less than 0.5 dE, which is within the acceptable
level. The silicone softener treated samples show increase in colour strength and yellower tone change compared with the non-ionic softener treated samples.

ii. The 0.5 to 1.0 reduction in light fastness rating was found in all finishing treatments, but formaldehyde free, anionic, non-ionic and nano silicone finishing induce very less reduction of 0.5 light fastness rating.

iii. Nano and micro emulsions of silicone show the resisting effect towards the colour bleeding of the dyed samples. Therefore, the colour depth of the dyed samples treated with silicone nano emulsion has higher values compared to conventional emulsion of silicone. The drying of the fabric with finish containing amino group causes the yellower tone change.

iv. Formaldehyde improves the colour wash fastness through cross linking reactions. Silicone nano and micro emulsion show the resisting effect towards the colour bleeding on the dyed samples.

v. The fixing agent forms a complex with the anionic dye which entraps the dye molecule and helps to avoid the dye to come out through fibre’s pores. The cationic softener also forms ionic bond with anionic dye which prevents the dye from coming out of the fibre. Wash fastness of non-ionic and anionic finished fabric are remaining the same as that of dyed samples.

vi. The dry rubbing fastness is not changed by the finish in grey shade. In Red shade, micro and macro silicone treatments deteriorate the dry rubbing fastness. As the macro silicone settle
on the surface of fibre and during rubbing, the macro silicone particle takes the dyes out and reduce the wet rubbing fastness.

vii. The macro silicone has more impact on light fastness than micro and nano-silicone softener. The reduction in fastness properties to sunlight exposure was due to the behaviour of silicone emulsion. This acts as a vehicle where the dye from the inside can possibly get transferred to the surface to humidity and sunlight.

viii. It is evident from the results that the nano emulsion causes less reduction in the fastness properties of the dyed samples compared to the conventional macro emulsion of silicone.

ix. The percentage contribution of process route on light fastness is found maximum influenced with pretreatment method and moderately contributed with finish used and less contribution by dyeing method is identified with the Taguchi method.

The conclusions drawn from the study on the effect of antioxidants and ultraviolet absorbers treatment on the fastness properties are listed below.

i. Fading rate curves for colour difference measurements of C.I. Reactive Yellow 84, C.I. Reactive Red 22 and C.I. Reactive Blue 198 dyed samples illustrates the fact that fading increases progressively with duration of light exposure.

ii. The application of ultraviolet absorbers and antioxidants causes the colour change in the dyed samples of brighter and bluer hue directions.
iii. The most efficient additives for C.I. Reactive Yellow 84 and C.I. Reactive Red 22 are vitamin C and gallic acid. For C.I. Reactive Blue 198, all the UV absorbers and antioxidants show a great improvement in the light fastness. The treatments on C.I. Reactive Yellow 84 and C.I. Reactive Blue 198 show significant improvement in fading as compared to C.I. Reactive Red 22 dyed fabric.

iv. The staining on multi fibre during wash fastness has not been significantly changed by the antioxidant and ultraviolet treatment.

v. The chemical treatment does not cause any significant change on dry rubbing fastness.

vi. The light fastness improvement chemical treatment by pad-dry-cure with acrylic binder gives 0.5 rating improvement in wet rubbing fastness. It is due to the bonding of chemicals and unfixed dyes on the fabric.

vii. It is observed that the durability of the chemical treatment is better in pad-dry-cure method than the exhaust method of application.

viii. Visible light requires oxygen to degrade the dyes. Usage of antioxidants like gallic acid, vitamin C and cafeic acid absorb the oxygen radicals available for photo degradation. The ultraviolet light is another important cause for fading of dyes and this reaction does not require oxygen.

ix. The combined application of antioxidant and ultraviolet absorbers improves the light fastness of reactive dyed fabric. The combined treatment of dyed samples with ultraviolet
absorbers and antioxidants significantly reduce the light fading in comparison with the individual treatment.

x. The best results are found in treatment with phenyl salicylate + vitamin C combination. The light fastness was tested under AATCC 16E, 20AFU method one rating improvement was found.
11.3 RECOMMENDATIONS FOR FUTURE WORK

The present investigation has paved way for further research on the following aspects.

i. Nowadays the usage of knitted cotton garments in the sports sector has increased. A major requirement of the sportswear is perspiration light fastness. Therefore effect of antioxidants and ultraviolet absorbers on perspiration light fastness can be taken up for further investigation.

ii. The chemicals used for this study are expensive commercialization of the invented light fastness improvement chemicals is not economical. Time-cost and environmental effect of these chemicals needs to be studied.

iii. Effect of yarn sizing and subsequent desizing agent on the light fastness of woven fabric is also an interesting topic to work further.