



A comparative study of application of ecofriendly natural dye on silk and cotton obtained from the flower of *Opuntia Ficus-Indica*

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ABSTRACT

This paper explains to extract the eco-friendly natural dye obtained from the flower of *Opuntia Ficus-Indica* and apply on silk and cotton fabric using combination of mordants. The fastness properties of the flower of *Opuntia Ficus-Indica* dyed silk and cotton fabric have been studied using different combination (1:3, 1:1 and 3:1) of various mordants. The wash, rub, light and perspiration fastness of the dyed samples have been evaluated. It is found that flower of *Opuntia Ficus-Indica* dye can be successfully used for the dyeing of silk and cotton to obtain a wide range colours.

Keywords: Cotton, Mordant, Natural dye, *Opuntia Ficus-Indica*, Silk

INTRODUCTION

The importance of this study of extracting dyes from plant (natural) sources is to avoid the environmental pollution. Present days with global concern over the use of eco-friendly and biodegradable materials, considerable research work is being undertaken around the world on the application of natural dyes in textile industry. The effluent problems of synthetic dyes occur not only during their application in the textile industry, but also during their manufacture and possibly during the synthesis of their intermediates and other raw materials. The use of natural dyes for textile dyeing purposes, decreased to a large extent after the discovery of synthetic dyes in 1856. Synthetic dye stuffs produce hazardous by-products some of which possess carcinogenic intermediates, and hence a ban has been imposed by Germany and some other European countries on the use of benzidine dyes in textile garments exported into their countries (Bains et al. 2003, Kumaresan et al. 2013). Hence, due to the current eco-consciousness, the attention of researchers has been shifted to the use of natural dyes for dyeing textile materials. Dyes derived from natural sources have emerged as an important alternative to synthetic dyes.

In the present work, the flower of *Opuntia Ficus-Indica* grows in all warm and damp parts of India. *Opuntia ficus-indica* (prickly pear) is a species of cactus that has long been a domesticated crop plant grown in agricultural economies throughout arid and semiarid parts of the world. Fig opuntia is grown primarily as a fruit crop, and also for the vegetable nopales and other uses. Most culinary references to the "prickly pear" are referring to this species. The name "tuna" is also used for the fruit of this cactus. Cacti are good crops for dry areas because they convert water into biomass efficiently. The wild origin of *O. ficus-indica* is likely to have been in Mexico due to the fact that its close genetic relatives are found in central Mexico.



Fig. 1 *Opuntia ficus-indica*

The dye was used to dye silk at optimized dyeing conditions, using combination of mordants (Bains et al. 2005, Kumaresan M 2015) and evaluate the resultant colour fastness of the dyed samples to washing, rubbing, perspiration and light.

MATERIALS AND METHODS

Materials: Bleached plain weave silk fabric, obtained from Gandhigram Rural University, Dindigal, was used for the study. AR grade ferrous sulphate, aluminium sulphate, nickel sulphate, potassium dichromate, stannous chloride, and commercial grade acetic acid, common salt and sodium carbonate were used. A natural mordant myrobolan (*Terminalia chebula*) powder (Bains et al. 2003, Kumaresan 2016) was used for the study. The ethanol extract of the flower of *Opuntia Ficus-Indica* was used to get pale brown colour for dyeing fabrics. Depending upon the mordant used, the colour obtained on textiles may give different shades.

A known quantity of flower of *Opuntia Ficus-Indica* was dried, powdered and soaked in warm water overnight. The flower of *Opuntia Ficus-Indica* extract was obtained by boiling it in the same water. The dye extract was allowed to cool, filtered and used for dyeing. The dyeing was carried out at optimized conditions namely dye extraction time 60 min, material to liquor ratio 1:20, and dyeing time 50 min.

The mordant combinations viz., myrobolan : nickel sulphate, myrobolan : aluminium sulphate, myrobolan : potassium dichromate, myrobolan : ferrous sulphate, and myrobolan : stannous chloride were used in the ratio of 1:3, 1:1 and 3:1. The total amount of two mordants used in each combination was 5% on the weight of the fabric i.e., 5 g of the mordant/100 g of the fabric. Each of the five mordant combinations in three different ratios mentioned above were used with all the three mordanting methods namely premordanting, simultaneous mordanting and postmordanting for dyeing (Gulrajani et al. 1992, Dr.M.Kumaresan et al 2017). After dyeing, the solution was allowed to cool, removed from dye bath, rinsed under running water to remove excess dye particles and shade dried.

Evaluation of colour fastness: Colour fastness to washing (Thomas Bechtold 2006) of the dyed fabric samples was determined as per IS: 764-1984 method using a Sasmira launder-O-meter following IS-3

wash fastness method. The wash fastness rating was assessed using grey scale as per ISO-05- A02 (loss of shade depth) and ISO-105-AO3 (extent of staining) and the same was cross-checked by measuring the loss of depth of colour and staining using Macbeth 2020 plus computer-aided colour measurement system attached with relevant software.

Colour fastness to rubbing (dry and wet) was assessed as per IS: 766-1984 method using a manually operated crock meter and grey scale as per ISO-105-AO3 (extent of staining). Colour fastness to exposure to light was determined as per IS: 2454-1984 method. The sample was exposed to UV light in a Shirley MBTF Microsal fade-O-meter (having 500 Watt Philips mercury bulb tungsten filament lamp simulating day light) along with the eight blue wool standards (BS1006: BOI: 1978). The fading of each sample was observed against the fading of blue wool standards.

Colour fastness to perspiration (Gulrajani et al. 1992, Dr.M.Kumaresan 2019), assessed according to IS: 971-1983 composite specimen, was prepared by placing the test specimen between two adjacent pieces of fabrics of silk and stitched all among four sides. The sample was soaked in the test solution (acidic/alkaline) separately with MLR 1:50 for 30 minutes at room temperature. The sample was then placed between two glass plates of perspirometer under load of 4.5 kg. The apparatus was kept in the oven for four hours at $37\pm 2^\circ\text{C}$. At the end of this period the specimen was removed and dried in air at a temperature not exceeding 60°C . The test samples were graded for change in colour and staining using grey scales.

RESULTS AND DISCUSSION

Mordant Combination-Myrobolan : Nickel Sulphate

The evaluation of colour fastness to light, washing, rubbing and perspiration of flower of *Opuntia Ficus-Indica* dyed silk and cotton samples treated with myrobolan: nickel sulphate combination in aqueous medium is presented in Table 1. All the treated samples subjected to light showed fairly good (3-4) light fastness for all ratio mordant combinations. The washing fastness grades ranged between 4 and 5-4 for all the treated samples and there was no colour staining. The colour change to dry and wet rubbing for all the treated samples was excellent (5). There was no colour staining to negligible colour staining (5 to 4-5) in dry rubbing and slight to noticeable staining in wet rubbing. Most of the treated samples showed excellent fastness grade to colour change in both acidic and alkaline media. There was no colour staining (5) for all the treated samples in both acidic and alkaline media are given in Table 1 and 2.

Table 1: Fastness grades of flower of *Opuntia Ficus-Indica* dye, dyed on silk at optimum dyeing conditions (wavelength 440 nm, dye extraction time 60min, material to liquor ratio 1:20, dyeing time 50 min.) using Mb:NS mordant combination.

Mordanting Method	Mordant Properties	Light Fastness Grade	Wash Fastness		Rub Fastness			Perspiration Fastness			
			Grades		Grades			Acidic		Alkaline	
			CC	CS	Dry		Wet	CS	CC	CS	CC
					CC	CS					
Pre Mordanting	1:3	3-4	4	5	5	5	5	4	5	4	5
	1:1	3-4	4-5	5	5	4-5	5	4	5	4-5	5
	3:1	3-4	4	5	4-5	5	5	5	5	5	5

Simultaneous Mordanting	1:3	3-4	4-5	5	5	5	5	5	5	5	5
	1:1	3-4	4	5	5	5	5	5	5	5	5
	3:1	3-4	4-5	5	5	4-5	5	4	5	5	5
Post Mordanting	1:3	3-4	4	4	5	5	5	4	5	5	4-5
	1:1	3-4	4-5	5	4-5	5	5	4	5	4-5	4-5
	3:1	3-4	4	5	5	5	5	4	5	5	5

Mb:NS – Myrobolan : Nickel sulphate, CC – Colour change, CS – Colour staining

Table 2: Fastness grades of flower of Opuntia Ficus-Indica dye, dyed on cotton at optimum dyeing conditions (wavelength 440 nm. dye extraction time 60min, material to liquor ratio 1:20, dyeing time 50 min.) using Mb:NS mordant combination.

Mordanting Method	Mordant Properties	Light Fastness Grade	Wash Fastness		Rub Fastness			Perspiration Fastness			
			Grades		Grades			Acidic		Alkaline	
			CC	CS	Dry		Wet	CS	CC	CS	CC
					CC	CS					
Pre Mordanting	1:3	3	3	4	4	4	4	4	4-5	4	5
	1:1	3	3-4	5	4	4-5	4	4	4	4-5	5
	3:1	3	3	5	4-5	5	5	5	5	5	5
Simultaneous Mordanting	1:3			5	5	5	5	5	5	5	5
	1:1	3	3-4	4	5	5	5	5	5	5	5
	3:1	3	3	5	5	4-5	5	4	5	5	5
Post Mordanting	1:3	3	3	4	5	5	5	4	5	5	4-5
	1:1	3	3-4	5	4-5	5	5	4	5	4-5	4-5
	3:1	3	3-4	5	5	5	5	4	5	5	5

Mb:NS – Myrobolan : Nickel sulphate, CC – Colour change, CS – Colour staining

Mordant Combination-Myrobolan : Aluminium Sulphate

The evaluation of colour fastness to light, washing, rubbing and perspiration of flower of Opuntia Ficus-Indica dyed silk samples treated with myrobolan : aluminium sulphate combination in aqueous medium is presented in Table 2. All the treated samples subjected to light showed fairly good (3-4) light fastness for all ratios of mordant combinations. The treated samples for premordanting showed fair (3 to 2-3) washing fastness grades, but they ranged between excellent to good (4-5 to 4) for all the treated samples for simultaneous and post mordanting. There was no colour staining. The colour change to dry and wet rubbing for all the treated samples was excellent (5). There was no colour staining ranged between no staining to negligible staining (5 to 4-5) in dry rubbing. There was slight colour staining, except for simultaneous mordanting method where it was negligible staining (4-5) in wet rubbing. The perspiration fastness grades ranged between 4-5 and 4, except for 1:3 mordant proportion in pre- mordanting method, where it was fair (3) for all the samples in both acidic and alkaline media. There was no colour staining (5) for all the treated samples in both acidic and alkaline media as given in Table 3 and 4.

Table 3: Fastness grades of flower of Opuntia Ficus-Indica dye, dyed on silk at optimum dyeing conditions (wavelength 440 nm. dye extraction time 60min, material to liquor ratio 1:20, dyeing time 50 min.) using Mb:AS mordant combination.

Mordanting Method	Mordant Properties	Light Fastness Grade	Wash Fastness		Rub Fastness			Perspiration Fastness	
			Grades		Grades			Acidic	Alkaline



			CC	CS	Dry		Wet	CS	CC	CS	CC
					CC	CS	CC				
Pre Mordanting	1:3	3-4	4	5	4	5	4-5	4	5	4	5
	1:1	3	5	5	4	4-5	4-5	4	5	4-5	5
	3:1	4	4	5	4	5	5	5	5	5	4-5
Simultaneous Mordanting	1:3	4	5	4-5	5	5	5	5	5	4-5	4-5
	1:1	4	5	4-5	5	5	5	5	5	5	5
	3:1	4	4-5	5	5	4-5	5	4	5	5	5
Post Mordanting	1:3	4	4	4	5	5	5	4	4	4-5	4
	1:1	3-4	4	4	4-5	5	4	4	4	4-5	4
	3:1	3-4	4	4	5	5	4	4	4-5	5	5

Mb:AS – Myrobolan : Aluminium sulphate, CC – Colour change, CS – Colour staining

Table 4: Fastness grades of flower of Opuntia Ficus-Indica dye, dyed on cotton at optimum dyeing conditions (wavelength 440 nm, dye extraction time 60min, material to liquor ratio 1:20, dyeing time 50 min.) using Mb:AS mordant combination.

Mordanting Method	Mordant Properties	Light Fastness Grade	Wash Fastness		Rub Fastness			Perspiration Fastness			
			Grades		Grades			Acidic		Alkaline	
			CC	CS	Dry		Wet	CS	CC	CS	CC
					CC	CS	CC				
Pre Mordanting	1:3	3	4	5	4-5	5	4-5	4-5	4-5	4	4-5
	1:1	3	5	5	4-5	4-5	4-5	4-5	4	4	5
	3:1	4	4	5	4	5	5	5	4	4-5	4-5
Simultaneous Mordanting	1:3	4	5	4-5	4	5	5	5	4	4-5	4-5
	1:1	4	5	4-5	4-5	5	5	5	5	5	5
	3:1	4-5	4-5	5	5	4-5	5	4	5	5	5
Post Mordanting	1:3	5	4	4	5	4	5	4	4	4-5	4-5
	1:1	3-4	4	4	4-5	4	4-5	4	4	4-5	4-5
	3:1	3-4	4	4	5	5	4-5	4	4-5	5	5

Mb:AS – Myrobolan : Aluminium sulphate, CC – Colour change, CS – Colour staining

Mordant Combination-Myrobolan : Potassium dichromate

The evaluation of colour fastness to light, washing, rubbing and perspiration of flower of Opuntia Ficus-Indica dyed silk samples treated with potash dichromate : copper sulphate combination in aqueous medium is presented in Table 3. The treated samples subjected to light showed fairly good (3-4) light fastness for all ratio mordant combinations. The washing fastness grades showed fairly good (3-4) for all the treated samples. The colour change to dry and wet rubbing for all the treated samples was excellent (5). The colour staining ranged between no staining to negligible staining (5 to 4) in rubbing and they ranged between negligible to slight colours staining (4-5 to 4) in dry wet rubbing. Most of the treated samples showed excellent fastness grade to colour change, except for 1:3 mordant proportion in simultaneous mordanting methods, where it was good (4) for all samples in both acidic and alkaline media. There was no colour staining (5) for all treated samples in both acidic and alkaline media are given in Table 5 and 6.

Table 5: Fastness grades of flower of Opuntia Ficus-Indica dye, dyed on silk at optimum dyeing conditions (wavelength 440 nm, dye extraction time 60min, material to liquor ratio 1:20, dyeing time 50 min.) using Mb:PD mordant combination.

Mordanting Method	Mordant Properties	Light Fastness Grade	Wash Fastness		Rub Fastness			Perspiration Fastness			
			Grades		Grades			Acidic		Alkaline	
			CC	CS	Dry		Wet	CS	CC	CS	CC
				CC	CS	CC	CS	CC	CS	CC	
Pre Mordanting	1:3	3-4	4	4	3	4	3	4	4	4	4
	1:1	3-4	4-5	4	3	3-4	3	4	4	4	4
	3:1	3-4	4	4	3	4	3	3	3-4	3-4	3
Simultaneous Mordanting	1:3	3-4	3-4	4	3-4	4	4	3	3-4	3-4	3-4
	1:1	3-4	3-4	4	3-4	4	4	3	3-4	3-4	4
	3:1	3-4	3-4	3-4	3-4	4	3-4	3	3	3	4
Post Mordanting	1:3	3-4	4	4	4	4	4	4	4	3	3-4
	1:1	3-4	4-5	3	3	3	3	4	4	3	3
	3:1	3-4	4	3	3	3	3	4	4	3-4	3-4

Mb:PD – Myrobolan : Potassium dichromate, CC – Colour change, CS – Colour staining

Table 6: Fastness grades of flower of Opuntia Ficus-Indica dye, dyed on cotton at optimum dyeing conditions (wavelength 440 nm, dye extraction time 60min, material to liquor ratio 1:20, dyeing time 50 min.) using Mb:PD mordant combination.

Mordanting Method	Mordant Properties	Light Fastness Grade	Wash Fastness		Rub Fastness			Perspiration Fastness			
			Grades		Grades			Acidic		Alkaline	
			CC	CS	Dry		Wet	CS	CC	CS	CC
				CC	CS	CC	CS	CC	CS	CC	
Pre Mordanting	1:3	3-4	4	4	4	4	3-4	3-4	4	3	4-5
	1:1	3	4-5	4	4	3-4	3-4	3-4	4	3-4	4
	3:1	3	4	4	4	4	3-4	3-4	3-4	3-4	3-4
Simultaneous Mordanting	1:3	3	3-4	4	3-4	4	4	3	3-4	3-4	3-4
	1:1	3	3-4	4	3-4	4	4	3-4	3-4	3-4	4
	3:1	3	3-4	3-4	3-4	4	3-4	3	3	3	4
Post Mordanting	1:3	3	4	4	4	4	4	3	4	3	3-4
	1:1	3-4	4-5	3	3	3	3	3-4	4	3	3
	3:1	3	4	3	3	3	3	3	4	3-4	3-4

Mb:PD – Myrobolan : Potassium dichromate, CC – Colour change, CS – Colour staining

Mordant Combination-Myrobolan : Ferrous Sulphate

The evaluation of colour fastness to light, washing, rubbing and perspiration of flower of Opuntia Ficus-Indica dyed silk samples treated with myrobolan : ferrous sulphate combination in aqueous medium is presented in Table 4. The treated samples subjected to light showed fairly good (4-3-4) light fastness for all ratios of mordant combinations. The washing fastness grades ranged from excellent to good (5-4) for all the treated samples. The colour change to dry and wet rubbing for all the treated samples was excellent (5). The colour staining ranged from no staining to slight staining (5 to 3-4) in dry rubbing slight to noticeable colour staining (4-5 to 3) in wet rubbing. Most of the treated samples showed excellent fastness grade to colour change, except for 1:3 mordant proportion in simultaneous mordanting method., where it was good (4) for all samples in both acidic and alkaline media. There was no colour staining (5)

for all the treated samples in both acidic and alkaline media as given in Table 7 and 8.

Table 7: Fastness grades of flower of Opuntia Ficus-Indica dye, dyed on silk at optimum dyeing conditions (wavelength 440 nm, dye extraction time 60min, material to liquor ratio 1:20, dyeing time 50 min.) using Mb:FS mordant combination.

Mordanting Method	Mordant Properties	Light Fastness Grade	Wash Fastness		Rub Fastness			Perspiration Fastness			
			Grades		Grades			Acidic		Alkaline	
			CC	CS	Dry		Wet	CS	CC	CS	CC
					CC	CS					
Pre Mordanting	1:3	3-4	4	4	4-5	5	5	4	4-5	4	4-5
	1:1	3-4	4-5	4	4-5	4-5	5	4	4-5	4-5	4-5
	3:1	3-4	4	4	4-5	4-5	5	4	5	5	4-5
Simultaneous Mordanting	1:3	3-4	3-4	4	5	5	5	5	5	5	5
	1:1	3-4	3-4	4	5	5	5	5	5	5	5
	3:1	3-4	3-4	3-4	5	5	5	5	5	5	5
Post Mordanting	1:3	3-4	4	4	5	4-5	4-5	4	4	5	4-5
	1:1	3-4	4-5	3	4-5	4-5	4-5	4	4-5	4-5	4-5
	3:1	3-4	4	3	4-5	4-5	4-5	4	4	4	5

Mb:FS – Myrobolan : Ferrous Sulphate , CC – Colour change, CS – Colour staining

Table 8: Fastness grades of flower of Opuntia Ficus-Indica dye, dyed on cotton at optimum dyeing conditions (wavelength 440 nm, dye extraction time 60min, material to liquor ratio 1:20, dyeing time 50 min.) using Mb:FS mordant combination.

Mordanting Method	Mordant Properties	Light Fastness Grade	Wash Fastness		Rub Fastness			Perspiration Fastness			
			Grades		Grades			Acidic		Alkaline	
			CC	CS	Dry		Wet	CS	CC	CS	CC
					CC	CS					
Pre Mordanting	1:3	4	4-5	4-5	4-5	4	5	4-5	4-5	4	4-5
	1:1	4	4-5	4-5	4-5	4	5	4-5	4-5	4-5	4-5
	3:1	4	4	4-5	4-5	4	5	4-5	5	5	4-5
Simultaneous Mordanting	1:3	4	3-4	4-5	5	4	5	4	5	4	4
	1:1	4	3-4	4	5	4	5	4	5	4	4
	3:1	4	3-4	3-4	5	4	5	4-5	5	4	5
Post Mordanting	1:3	3-4	4	4	5	4-5	4-5	4	4	5	4-5
	1:1	3-4	4-5	3	4-5	4-5	4-5	4	4-5	4-5	4-5
	3:1	3-4	4	3	4-5	4-5	4-5	4	4	4	5

Mb:FS – Myrobolan : Ferrous Sulphate , CC – Colour change, CS – Colour staining

Mordant Combination-Myrobolan : Stannous Chloride

The evaluation of colour fastness to light, washing, rubbing and perspiration of flower of Opuntia Ficus-Indica dyed silk samples treated with myrobolan : stannous chloride combination in aqueous medium is presented in Table 5. The treated samples subjected to light showed fairly good (4 to 3-4) light fastness for all the ratios of mordant combinations. The washing fastness grades ranged between excellent to good (4-5 to 3-4) for all the treated samples and there was no colour staining. The colour change to dry and wet rubbing for all the treated samples was excellent (5). The colour staining ranged from negligible to slight staining (4-5) in both dry and wet rubbing. The perspiration fastness grades ranged between 4 and 5 for all samples in both acidic and alkaline media. There was no colour staining (5) for

all the treated samples in both acidic and alkaline media as given in Table 9 and 10.

Table 9: Fastness grades of flower of Opuntia Ficus-Indica dye, dyed on silk at optimum dyeing conditions (wavelength 440 nm. dye extraction time 60min, material to liquor ratio 1:20, dyeing time 50 min.) using Mb:SC mordant combination.

Mordanting Method	Mordant Properties	Light Fastness Grade	Wash Fastness		Rub Fastness			Perspiration Fastness			
			Grades		Grades			Acidic		Alkaline	
			CC	CS	Dry		Wet	CS	CC	CS	CC
		CC	CS	CC							
Pre Mordanting	1:3	3-4	4	4	3-4	4	3-4	4	3-4	3-4	4
	1:1	3-4	4-5	4	3-4	4	4	4	4	4	4
	3:1	3-4	4	4	4	3-4	4	4	3-4	3-4	3
Simultaneous Mordanting	1:3	3-4	4-5	4	4	4	4	4	3-4	3-4	3-4
	1:1	3-4	4-5	4	4	4	4	4	3-4	3-4	4
	3:1	3-4	4	4-5	3-4	3-4	3-4	4	3	4	4
Post Mordanting	1:3	3-4	4-5	4	4	4	4	4	4	4	4
	1:1	3-4	4-5	4	3-4	3-4	3-4	4	4	4	4
	3:1	3-4	4	4	3-4	3-4	3-4	4	4	4	4

Mb:SC – Myrobolan : Stannous Chloride, CC – Colour change, CS – Colour staining

Table 10: Fastness grades of flower of Opuntia Ficus-Indica dye, dyed on cotton at optimum dyeing conditions (wavelength 440 nm. dye extraction time 60min, material to liquor ratio 1:20, dyeing time 50 min.) using Mb:SC mordant combination.

Mordanting Method	Mordant Properties	Light Fastness Grade	Wash Fastness		Rub Fastness			Perspiration Fastness			
			Grades		Grades			Acidic		Alkaline	
			CC	CS	Dry		Wet	CS	CC	CS	CC
		CC	CS	CC							
Pre Mordanting	1:3	3-4	3	4-5	4	4-5	3-4	4-5	3-4	3-4	4-5
	1:1	3-4	3-4	4	4	4-5	4	4-5	4	4	4-5
	3:1	3-4	3-4	4-5	4-5	3-4	4	4-5	3-4	3-4	3-4
Simultaneous Mordanting	1:3	3-4	3	4	4-5	4	4	4	3-4	3-4	3-4
	1:1	3-4	3	4-5	4	4	4	4	3-4	3-4	4
	3:1	3-4	3-4	4-5	4-5	3-4	3-4	4	3	4	4
Post Mordanting	1:3	3-4	3-4	4	4-5	4	4	4-5	4-5	4	4
	1:1	3-4	4-5	4	3-4	3-4	3-4	3-4	4	4	4
	3:1	3-4	4	4	3-4	3-4	3-4	4	4	4	4

Mb:SC – Myrobolan : Stannous Chloride, CC – Colour change, CS – Colour staining

CONCLUSION

It was found from the study that flower of Opuntia Ficus-Indica dye can be successfully used for dyeing silk and cotton to obtain a wide range of soft, pastel and light colours by using combination of mordants. With regards to colour fastness, test samples exhibited excellent fastness to washing (except for pre-mordanting using myrobolan : potassium dichromate combination); excellent fastness to rubbing (except for pre-mordanting using myrobolan : potassium dichromate combination); and good to excellent fastness to perspiration in both acidic and alkaline media and fairly good fastness to light. Comparing all the fastness properties dyed cotton fabric showed an excellent result when compared to the silk fabric.

ACKNOWLEDGEMENT

The authors are thankful to Dr.P.N.Palanisamy, Department of Chemistry, Kongu Engineering College for his support and help for the completion of this work.

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