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Effect of lac dyeing on colour fastness of silk yarn*

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Abstract: A natural colourant extracted from lac insect (*Laccifer lacca*), grown abundantly in India over hundred and twenty host plants was utilized for colouration of mulberry silk yarn. Four different mordants at three dye concentrations were tried on silk yarn to assess the colour fastness properties of the dyed samples. It was found that, fastness properties were influenced by the dye concentrations and type of mordants used.

Key words: Colour fastness, Lac dye, Mulberry silk, Natural dye

Introduction

Dyeing is an ancient art as well as modern complex science. Primitive people have been endeavoring to add colour to the world around them. Primitive dyeing technique includes stamping plants to fabric or rubbing crushed plant pigments on to the cloth. Dyeing according to the dictionary, may be defined as "The process of colouring fibres, yarn or fabric by using a liquid containing colouring matter for imparting a particular hue to a substance". Natural dyes are colourants that are obtained from animal or vegetable matter. In recent years, there is a growing interest in the use of natural dyes due to the stringent environmental standards imposed by many countries in response to the toxic and allergic reactions associated with synthetic dyes. Natural dyes exhibits better bio-degradability and are generally more compatible with the environment. The scenario of natural dyeing is gradually making its way in the global market and the production of eco-friendly naturally dyed textiles itself is a boon to save the environment from hazardous synthetic dyes. Though natural dyes are not as brilliant as synthetic dyes but are invariably usual. Hence, naturally dyed textiles shall help the entrepreneurs to take up this venture.

Natural dyes are broken down into two categories such as substantive and adjective (non-substantive). Substantive dyes are chemically bound to the fibre without any colour fixing agents (mordants) *viz.*, indigo, turmeric *etc.,* Majority of the natural dyes being non-substantive are used in conjunction with mordants (Paul, *et.al.,* 1996) The word 'mordant' has been derived from the latin word 'modere' meaning 'to bite'. The mordant (usually a metallic salt) 'bites' the surface of the substrate i.e. fibre thus, creating an affinity between the fibre and dye molecules. Mordant forms a complex between fibre and dye, which is insoluble in water and thus gives a fast colour. (Gohl and Vilensky, 1987).

Lac dye is one of the insect dyes. History of lac dates back to Vedic period. The term 'lac' is derived from Sanskrit word 'laksha' meaning 'one lakh', which is descriptive of number of lac insects that infest their host plants. India is the premier country in the world to produce lac and it's by products followed by China and Thailand. Lac cultivation is practiced in Northern States of India *viz.,* Bihar, Jharkhand, Chattisgarh, Madhya Pradesh, Uttar Pradesh and some parts of Orissa and Maharashtra (Agarwal, 1997). The insect survives on the succulent green branches of host plants namely, kusum *(Schleicherm oleosa)*, palas (*Butea monosperma)*, ber (*Zizyphus mauritiana*), and cajanus (*Cajanus cajana*) and completes it's life cycle within six months. During the life cycle it secretes reddish brown gelatinous substance around the branches of host plants, which gives stick lac. Stick lac is made into shellac (by product of lac) by thoroughly washing in plain water. The water-soluble dye pigment, laccaic acid is taken for further extraction of lac dye. Indian lac dye has high potentiality through out the world for its use as textile colouring material in textile industry as well as food colouring substance in food industry.

Material and methods

The multivoltine yellow race mulberry (*Bombyx mori*) silk yarn was dyed with Lac (*Laccifer lacca*) at 5,10 and 15 per cent concentration and the mordant's used were Potash Alum $AlK(SO_4)_2$, Copper Sulphate ($CuSo_4$), Citric Acid ($C_6H_80_7$) and Stannous Chloride ($SnCl_2$). Specimen dyed without mordant was considered as control.

The dyeing technique developed by Indian Lac Research Institute (ILRI), Namkum, Ranchi, Jharkhand was adopted in the present study. One per cent stock solution was prepared by boiling the powdered lac dye with water (100 parts) and borax (1part) for 20 minutes and filtered through fine muslin cloth.

Dye recipe:

M L R	-	1:50
Common salt	-	15% OWM (on weight of material)
Temperature	-	Boiling
Time	-	60 min
Mordant concentration		2%

The dye bath was set with required quantity of water, stock solution and common salt. The pH of the dye bath was maintained acidic by the adding acetic acid. After 10 minutes the degummed silk yarn was entered into the dye bath at 60^0 C and stirred continuously. Temperature of the dye bath was raised gradually to boil within 15 minutes and dyed for an hour. Simultaneously, the required mordant was added to the dye bath to obtain desired shade.

Soaping is a necessary after treatment to remove the traces of acid and other chemical reagents after dyeing, where the

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Table 1. Effect of crocking on colour fastness (ratings)

Mordants	Dye concentration (%)	Colour fastness to crocking			
		Dry		Wet	
		Change in colour	Stain on staining material	Change in colour	Stain on staining material
Control 5	3	3	3	-3	
	10	3	2-3	3	2-3
	15	3	2-3	3	3
Potash Alum ($Alk(SO_4)_2$)	5	4-5	4	3-4	3
	10	4-5	4	3-4	3
	15	4	4	3-4	3
Copper Sulphate ($CuSO_4$)	5	4-5	3	4	2-3
	10	4	3	4	2-3
	15	4	3	3-4	3
Citric Acid ($C_6H_8O_7$)	5	4	4	4	3
	10	4	4	3-4	3
	15	4	4	4	3
Stannous Chloride ($SnCl_2$)	5	5	4	4	3
	10	4-5	4-5	4	3
	15	4	4-5	4	3

dyed sample was worked with 1:40 MLR in 0.5 gpl soap solution at boiling for 15 minutes, finally washed and shade dried.

The dyed samples were assessed for colour fastness to crocking, perspiration, light and washing as per IS test methods 766-1988, 971-1983, 686-1985 and 687-1979 respectively.

Results and discussion

The findings of the present study are discussed here below: From Table 1, it is noticed that, irrespective of mordants and dye concentrations the colour fastness for dry crocking was found to be better compared to wet. This may be due to the breakage of dye metal complexes into simple particles during wet rubbing and the release of superficially deposited dye molecules from dry substrate to wet, thus resulting into remarkable stain on staining the material. Among the mordanted samples stannous chloride ($SnCl_2$), exhibited good to excellent (4-5) fastness to dry crocking and fair to good (3-4) for wet crocking. The samples dyed at 5 per cent dye concentration exhibited better fastness compared to 10 and 15 per cent, because in later instances, there was physical adherence of excess dye particles on the textile material after saturation, that was released from the fabric in wet condition thus, staining the material. The mordanted specimen showed better fastness than control, thus confirming that mordant plays a vital role in breaking the surface tension of the fibre there by assisting the dye molecule to penetrate into the fibre core. Further observations revealed that stain on staining material was relatively obvious than change in the colour. It was also observed that the specimen mordanted with Stannous Chloride ($SnCl_2$) showed good to excellent (4-5) colour fastness compared to Potash Alum ($Alk(SO_4)_2$), Citric Acid ($C_6H_8O_8$) and Copper Sulphate ($CuSO_4$). These results are supported by the authors *viz.,* Gulrajani *et al.,* (1993), Sudhakar and Ninge Gowda (2005), Singh (2000).

Table 2 illustrates the effect of acidic and alkaline perspiration of lac dyed samples for change in colour and stain on cotton and silk materials. Irrespective of dye concentrations the mordanted samples exhibited fair to good (3-4) fastness than control which was poor to fair (2-3), the stain on cotton material was relatively lower than silk. Irrespective of mordants and dye concentrations the colour fastness to acidic perspiration was better than alkaline due to the stable electronic configuration of silk in acidic conditions. Further the stain on cotton, one of the adjacent materials of composite samples in acidic perspiration was found to be relatively less than alkaline; whereas it was almost same on silk material in both pHs.

The effect of sunlight on colour fastness of lac dyed silk yarn is presented in Table 3. Irrespective of dye concentrations the specimen mordanted with Potash Alum $AlK(SO_4)_2$, Copper Sulphate ($CuSo_4$), Citric Acid ($C_6H_80_7$) and Stannous Chloride ($SnCl_2$) showed very fair to good (4-5) light fastness compared to non mordanted samples, which may be due to, the formation of metal dye complex resulting into better penetration of dye molecules in the fibre matrix. The specimen treated with all the four mordants did not show much fading on exposure to sunlight for 48 hours. In general, light fastness of lac dyed silk was fair to good because of higher wave length of red dyes. These results are in line with the results revealed by Gulrajani *et al.*(1993) in the study on dyeing with red natural dyes.

The loss of colour during laundering is referred to as a lack of wash fastness or bleeding. From the table 4 it is clear that irrespective of dye concentrations, the non mordanted specimen exhibited very poor (1-2) wash fastness, on the contrary mordanted specimen expressed fair to good (3-4) fastness to washing. As majority of the red natural dyes are water soluble, mordants create sites which attracts dye molecules to penetrate into the core of the fibre. The specimen dyed with Citric Acid ($C_6H_8O_7$) showed good to excellent (4-5) colour fastness followed by Stannous Chloride ($SnCl_2$) and Copper Sulphate ($CuSO_4$) whereas, the fastness was fair to good (3-4) when mordanted with Potash Alum ($Alk(SO_4)_2$). This may be due to the stable electronic arrangement formed by acid mordant resulting into greater resistance to chemical degradation. Selections of mordants do affect the wash fastness of red natural dyes.

Table 2. Effect of perspiration on colour fastness (ratings)

Mordants	Dye concentration (%)	Change in colour	Colour fastness to perspiration				
			Acidic			Alkaline	
			Stain on staining material		Change in colour	Stain on staining material	
			Cotton	Silk		Cotton	Silk
Control5	2-3	4	3	2-3	4-5	3-4	
	10	2-3	4	3	3	4	3-4
	15	3	4	3	3	4	4
Potash Alum ($Alk(SO_4)_2$)	5	3-4	4	3	2	2-3	3
	10	4	4	3	2-3	3	3-4
	15	4-5	4	3-4	3	3	3-4
Copper Sulphate ($CuSO_4$)	5	3	4	3	3-4	3	3-4
	10	3-4	4	3	3	2-3	3-4
	15	4-5	4	3-4	3-4	2-3	3-4
Citric Acid ($C_6H_8O_7$)	5	3-4	4	3	3	4	3-4
	10	4-5	4	3-4	4	3-4	4
	15	5	4-5	3-4	4	3-4	4-5
Stannous Chloride ($SnCl_2$)	5	3	3-4	2-3	3	4	4
	10	4	4	3	3-4	3-4	4
	15	4	4	3	4	3-4	4

Table 3. Effect of sunlight on colour fastness (ratings)

Mordants	Dye Colour concentration (%)	No fastness
Control	5	3-4
	10	4
	15	4
Potash Alum ($Alk(SO_4)_2$)	5	4-5
	10	4-5
	15	5
Copper Sulphate ($CuSO_4$)	5	4-5
	10	5
	15	5
Citric Acid ($C_6H_8O_7$)	5	4-5
	10	5
	15	5
Stannous Chloride ($SnCl_2$)	5	4
	10	4-5
	15	5

Table 4. Effect of washing on colour fastness (ratings)

Mordants	Dye concentration (%)	Change in colour	Stain on staining material	
			Cotton	Silk
Control	5	1	4-5	4-5
	10	1	4-5	4
	15	1-2	4-5	4-5
Potash Alum ($Alk(SO_4)_2$)	5	2	3-4	3-4
	10	2-3	3-4	3-4
	15	2-3	3	3-4
Copper Sulphate ($CuSO_4$)	5	3	4-5	4-5
	10	3	4-5	4-5
	15	3-4	4-5	4-5
Citric Acid ($C_6H_8O_7$)	5	3	4-5	4-5
	10	3-4	4-5	4-5
	15	4-5	4-5	5
Stannous Chloride ($SnCl_2$)	5	3	4-5	4-5
	10	3-4	4	4-5
	15	3-4	4-5	4-5

The colour fastness of lac dyed silk yarn was fair to good because of the higher wavelength of red dyes. Mordanted specimen showed better fastness for crocking, perspiration, sunlight and washing compared to control because, each mordant created affinity between fiber and dye molecules and assisted the dye molecule to penetrate into the fiber core resulting into fast colour. The dyed specimen showed good to excellent fastness for crocking compared to perspiration, sun light and laundering. The test samples exhibited better colour fastness for acidic perspiration than alkaline due to the stable electronic configuration of silk in acidic conditions, therefore during laundering neutral or acidic soaps should be used. Moreover fair to good colour fastness of lac dyed samples to crocking, sunlight and washing may be overcome by avoiding hard brushing, shade drying and use of exhausting agents during laundering.

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