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ECO–FRIENDLY NATURAL DYES FROM *HIBISCUS VITIFOLINS* AND *SESBANIA AEGYPTIACA* FOR DYEING

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ABSTRACT

The dye extracts have been obtained from *Hibiscus vitifolins* (HV) and *Sesbania aegyptiaca* (SA). These dye extracts have been applied on both bleached cotton and silk fabrics. Excellent colour shades and hues resulted on cotton and silk cloth samples when dyed using pre–mordanting, post–mordanting and simultaneous mordanting methods. The samples have shown good light and rubbing fastness properties.

Key words : Natural dyes, *Hibiscus vitifolins*, *Sesbania aegyptiaca*, Dyeing

INTRODUCTION

Man is fascinated by colours. Colour may be of natural origin or synthetically developed. In the history of civilisation of man, he started using colours long before. Plant and animal extracts were initially used. They were chiefly of monochromatic colour, viz., indigo violet, pink, yellow. Perkin[1] accidentally discovered synthetic dye, Mauve (Mavevine). Followed by this, a wide variety of synthetic dyes have been developed. These dyes have been applied on all kinds of both synthetic and natural yarns, fabrics and knitted fabrics.

Man's health and environment slowly but definitely affected by these synthetic dye substances. Most of the synthetic dyes are carcinogenic, mutagenic and sensitizing. In 1994 German Government[2] has banned all the textile goods which are dyed with some azo dyes obtained from aryl amines. The reason for this is that these dyes liberate caroinogenic amines which are harmful to human beings. Another factor is that the raw materials are obtained from petroleum sources. The reaction conditions are drastic. Most of them are toxic in nature. This creates more problem to the textile processing and dyeing industries[3].

Awareness has dawn on man to search for an alternative to end this menace. His attention has now been focused on natural resources to get colouring substances.

In certain parts of our country, people are using naturally occuring dyes to impart colour to cotton and silk yarn and fabrics. Traditional methods are used to prepare dye solutions and to apply them on yarns and fabrics. Different colours and hues are excellently developed through

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simple, inexpensive methods. These and other observations have initiated the study of development of dyes from natural resources.

Having surveyed the available literature, it has been proposed to investigate the potential of *Hibiscus vitifolins* and *Sesbania aegyptiaca* plant extracts as dye substances.

The flower extracts of the plant *Hibiscus vitifolins* produces a maroon solution and the yellow part of the flower yields a yellow solution. The flower extract of the plant *Sesbania aegyptiaca* yields a brown solution. These dye extracts have been used for dyeing bleached fabrics of cotton, silk and wool.

EXPERIMENTAL

Collection and preparation of materials

Collection of sources : Flowers of *Hibiscus vitifolins* (HV) and *Sesbania aegyptiaca* (SA) were collected from the areas in and around Erode.

Extraction of dye from HV and SA : The petals of the flowers of *Hibiscus vitifolins* and *Sesbania aegyptiaca* were plucked early in the morning. These petals were cut into small pieces and placed in a vessel containing methanol and allowed to simmer for about one hour. The collected dye extract was evaporated to remove the solvent. In each case, the dye was obtained in a pasty form. From this paste, a dye solution of required concentration was prepared for various dyeing operations.

Preparation of materials

Cotton : The cotton fabric in grey form was desized, scoured and bleached well. It was cut into small pieces for dyeing with the dye extracts.

Silk : Degummed and bleached silk fabric was cut into small pieces for dyeing with the dye extracts.

Chemicals used

Alkali used : Glauber's salt.

Exhausting agent : Sodium chloride

Metal salts

(a) Copper sulphate
(b) Ferrous sulphate
(c) Nickel sulphate
(d) Potassium dichromate
(e) Stannous chloride
(f) Aluminium sulphate
(g) Ferrous ammonium sulphate (FAS)
(h) Ammonium chloride
(i) Zinc sulphate

Dyieng of cotton with extract from *Hibiscus vitifolins* (HV) and *Sesbania aegyptiaca* (SA)

Dyeing with dye extract : The wetted out cotton samples were dyed with dye extract using the following recipe.

Recipe : Dye concentration was 2% for HV and 5% for SA. The sodium sulphate and sodium chloride concentration was 2% for dyeing. The M : L ratio was 1 : 20 for both dyeing and mordanting. The temperature was kept constant at 50° C for both.

Procedure : The wetted out cotton samples were entered into dye baths containing required amount of dye extract and water. After 10 minutes, required amount of sodium sulphate and after 20 minutes, required amount of sodium chloride were added. The dyeing was carried out for one hour at 50°C. The dyed samples were taken out, rinsed with water, squeezed and dried.

Cotton fabrics were dyed and mordanted using the following three methods.

- Pre–Mordanting (PRM)
- Simultaneous Mordanting (SM)
- Post–Mordanting (POM)

For all the three methods, the metal concentration was kept constant at 5%.

Pre–Mordanting : The wetted out cotton samples were pre–mordanted using the above metal concentration for half an hour at 50°C. The samples were squeezed and used for dyeing process without washing. The mordanted fabric was then dyed as per the recipe and the procedure mentioned above.

Simultaneous Mordanting : The mordant was put in dye liquor and the fabric was then dyed and mordanted simultaneously.

Post–Mordanting : The fabric was first dyed followed by mordanting.

Dyeing of silk with extract from *Hibiscus vitifolins* (HV) and *Sesbania aegyptiaca* (SA)

Dyeing with dye extract : The wetted out silk fabrics were dyed with dye extract using the following recipe.

Recipe : Dye concentration was 2% for HV and 5% for SA. The acetic acid concentration was kept 2% for dyeing. The M : L ratio was 1 : 20 for both dyeing and mordanting. The temperature was kept constant at room temperature (32°C) for both.

Procedure : The wetted out silk fabrics were entered into dye baths contatining required amount of dye extract, acetic acid and water. The dyeing was carried out for one hour at room temperature (32°C). The dyed samples were taken out, rinsed with water, squeezed and dried.

Silk fabrics were dyed and mordanted using the following three methods.

- Pre–Mordanting (PRM)
- Simultaneous Mordanting (SM)
- Post–Mordanting (POM)

For all the three methods the metal concentration was kept constant at 5%.

Pre–Mordanting : The wetted out silk fabrics were mordanted using the above metal concentration for half an hour at room temperature (32°C). The samples were squeezed and used for dyeing process without washing. The mordanted fabric was then dyed as per the recipe and the procedure mentioned above.

Simultaneous Mordanting : The mordant was put in dye liquor and the fabric was then dyed and mordanted simultaneously.

Post–Mordanting : The fabric was first dyed followed by mordanting.

RESULTS AND DISCUSSION

The dye extracts obtained from plant source *Hibiscus vitifolins* and *Sesbania aegyptiaca* and their dyeing properties with cotton, silk and wool studies have shown some interesting results.

Quantum yield of dye extract

The quantum yield of the colouring matter from *Hibiscus vitifolins* has been found to be 4% and from *Sesbania aegyptiaca* it has been found to be 3%. The colour of the dye extract of the brown part of the flower of *Hibiscus vitifolins* was maroon and its yellow part was yellow. The colour of dye extract of the flower *of Sesbania aegyptiaca* was brown.

Dyeing properties

The natural dyes from the flower of *Hibiscus vitifolins* and *Sesbania aegyptiaca* were found to be suitable for dyeing of cotton and silk. These fabrics were dyed with or without metallic salts. The dye extracts were found to be not suitable for dyeing bleached wool.

It is imperative that the yellow extract may contain flavonoids, brown dye solution may consist of quinone structure and maroon extract may be a mixture of hydroxyanthraquinone molecules. These well–known organic molecules were found to be mordanted with metal ions to yield different colours on yarns and fabrics[4].

Effect of metal salts

The dye extracts of HV and SA have been applied on cotton and silk fabrics. The well–established methods of dyeing–pre–mordanting, simultaneous mordanting and post–mordanting were carried out.

The different metal salts with dye extracts produce different colours and hues. All the results obtained have been depicted by pasting the samples. The identification of the colour was done with the shade cards available in the market. (Table 1 to 7).

Table 1. Colours obtained on cotton with different metal salts using *Hibiscus vitifolins* extract (Yellow portion)

Metal Salts	PRM	SM	POM
$CuSO_4$	LSABARI (SRD)	TATA MIMOSO (AP)	KHAKHI (SRD)
$FeSO_4$	KHAKHI (SRD)	SABARI (SRD)	BEENA (SRD)
$NiSO_4$	TATA MIMOSO (AP)	DAFFODIL (SRD)	MEADOW FLOWER (DU)
$K_2Cr_2O_7$	RAW SILK (SRD)	BADAMI (SRD)	V.L.MILITARY (SRD)
$SnCl_2$	SHENBAGAPOO (SRD)	MUSTARD (SRD)	D.LEMON (SRD)
$Al_2(SO_4)_3$	MEKHALA (SRD)	MEADOW FLOWER (DU)	HONEYDEW (DU)
FAS	KHAKHI (SRD)	SUMMER SAND (TD)	TUSSUR (SRD)
NH_4Cl	HALCYON (DU)	MEADOW FLOWER (DU)	HALCYON (DU)
$ZnSO_4$	PEARL (SRD)	MOHINI (SRD)	MEADOW FLOWER (DU)

Table 2. Colours obtained on silk with different metal salts using *Hibiscus vitifolins* extract (Yellow Portion)

Metal Salts	PRM	SM	POM
$CuSO_4$	DATTODIL (N)	MOHINI (SRD)	SRI RANJANI (SRD)
$FeSO_4$	TATA MIM (LU)	AUTUMN GOLD (DU)	TATA MIM (LU)
$NiSO_4$	MEADOW FLOWER (DU)	MOHINI (SRD)	MOHINI (SRD)
$K_2Cr_2O_7$	SRIRANJANI (SRD)	L.SAMPANGI (SRD)	L.SAMPANGI (SRD)
$SnCl_2$	LATHA (SRD)	MIDBUFF (LU)	G.MUSTARD (SRD)
$Al_2(SO_4)_3$	PEARL (SRD)	D.LEMON (SRD)	MOHINI (SRD)
FAS	AUTUMN GOLD (DU)	TATA MIM (LU)	APSARA (SRD)
NH_4Cl	SRIRANJANI (SRD)	MEADOW FLOWER (DU)	TATA MIM (LU)
$ZnSO_4$	PRIMROSE (TD)	MEADOW FLOWER (DU)	MOHINI (SRD)

Table 3. Colours obtained on cotton with different metal salts using *Hibiscus vitifolins* extract (Brown Portion)

Metal Salts	PRM	SM	POM
$CuSO_4$	VENETIAN GREEN (TD)	VENETIAN GREEN (TD)	MIST GREY (SS)
$FeSO_4$	STAR DUST (DU)	NEW T.A. GREY (R)	SILVER GREY (SS)
$NiSO_4$	APPLE GREEN (SS)	PAMPADOUR (DU)	PAMPADOUR (DU)

Continued...

Table 3 Continued.,...

Metal Salts	PRM	SM	POM
$K_2Cr_2O_7$	PEPERMINT (SS)	BLUE BELL WHITE HINT (DU)	SWEDE BLUSH (N)
$SnCl_2$	LIGHT COFFEE (DU)	ICE BREAKER (DU)	SWEDE BLUSH (N)
$Al_2(SO_4)_3$	MIST GREY (SS)	NEW LAVENDER (N)	STING (DU)
FAS	SILVER GREY (SS)	SILVER (DU)	LIGHT GREY (R)
NH_4Cl	MARBLE GREY (SS)	ACONITE (DU)	BLUE BELL WHITE HINT (DU)
$ZnSO_4$	DUCK EGG (SS)	SILVER GREY (SS)	MERRIE PINK (N)

Table 4. Colours obtained on silk with different metal salts using *Hibiscus vitifolins* extract (Brown Portion)

Metal Salts	PRM	SM	POM
$CuSO_4$	VENETIAN GREEN (TD)	CHAMOIS (LU)	LIGHT COFFEE (DU)
$FeSO_4$	MUSHROOM (AP)	MUSHROOM (AP)	MAGNOLIA (DU)
$NiSO_4$	NICKEL GREY (AP)	DESERT PINK (DU)	VENETIAN GREEN (TD)
$K_2Cr_2O_7$	PALE CREAM (LU)	PALE CREAM (LU)	PALE CREAM (LU)
$SnCl_2$	BLUEBELL WHITE HINT (DU)	SAND STONE (LU)	CHAMOIS (LU)
$Al_2(SO_4)_3$	MERCURY (SRD)	MERCURY (SRD)	PALE LILAC (TD)
FAS	R.GREY (LU)	NICKEL GREY (AP)	SABAR (SRD)
NH_4Cl	NICKEL GREY (AP)	MUSHROOM (N)	TUSSUR (SRD)
$ZnSO_4$	MUSHROOM (AP)	PALE LILAC (TD)	PALE LILAC (TD)

Table 5. Colours obtained on cotton with different metal salts using *Sesbania aegyptiaca* extract

Metal Salts	PRM	SM	POM
$CuSO_4$	VENETIAN GREEN (TD)	PARCHMENT (DU)	GREY GHOST (DU)
$FeSO_4$	AIRSTREAM (DU)	OYSTER WHITE (DU)	AIR CASTLE (DU)
$NiSO_4$	TULLE WHITE (DU)	IVORY SAMPLER (DU)	SOFT ECRA (DU)
$K_2Cr_2O_7$	MAGNOLIA (TD)	ANTIQUE WHITE (DU)	GREY GHOST (DU)
$SnCl_2$	PARCHMENT (DU)	MUSHROOM (AP)	IMPNRIONISM (DU)
$Al_2(SO_4)_3$	LARISH LARENDER (DU)	SILVER (DU)	AIR STREAM (DU)
FAS	SILVER (DU)	WATER CHESNUT (DU)	NICKEL GREY (AP)
NH_4Cl	ICE CAP (DU)	AIR STREAM (DU)	ICE CAP (DU)
$ZnSO_4$	FEST WHITE (LU)	STAR DUST (DU)	PORCELAIN (TD)

Table 6. Colours obtained on silk with different metal salts using *Sesbania aegyptiaca* extract

Metal Salts	PRM	SM	POM
$CuSO_4$	MUSHROOM (AP)	MUSHROOM (AP)	SILVER (DU)
$FeSO_4$	MILL STONE (DU)	NICKEL GREY (AP)	NICKEL GREY (DU)
$NiSO_4$	NICKEL GREY (DU)	SILVER (DU)	STAR DUST (DU)
$K_2Cr_2O_7$	LINING SILVER (SRD)	SILVER (DU)	BEENA (SRD)
$SnCl_2$	NEW LAVENDER (N)	MILL STONE (DU)	CASCADE (TD)
$Al_2(SO_4)_3$	STING (DU)	NICKEL GREY (AP)	DEWDROP (TD)
FAS	NEW TA GREY (R)	MUSHROOM (AP)	LIGHT GREY (AP)
NH_4Cl	NICKEL GREY (AP)	AUTUNM GREY (N)	STAR DUST (DU)
$ZnSO_4$	MUSHROOM (AP)	MUSHROOM (AP)	STEEL (TD)

Table 7. Colours obtained on cotton and silk with dye extract

Dye extracts	Cotton	Silk
HA (Brown)	PAMPADOUR (DU)	LIGHT COFFEE (DU)
HA (Yellow)	MEADOW FLOWER (DU)	HONEY DEW (DU)
SA	RUSSIAN WHITE (DU)	NICKEL GREY (AP)

R = Rohini Paints
DU = Dulux Paints
TD = Tractor Distemper (Asian Paints)
LU = Luxol Hi–Gloss (Berger Paints)
AP = Apcolite (Asian Paints)
N = Nerolac Paints
SS = Super Sivacem Water Proof Cement Paints
SRD = Sri Ramakrishna Dyeing Works

Effect of exhausting agent

Sodium chloride has been used as an exhausting agent. It has been observed that it has no effect on dye uptake. But the levelness of dyeing was found to be good.

Effect of temperature

It has been observed that an increase in temperature decreases the dye uptake, whereas the dyeing of samples at 50°C yield better results rather than at room temperature.

Fastness properties

The light and rubbing fastness properties of these dyed fabrics were studied.

Rubbing fastness : The rubbing fastness of the dyed samples were assessed by a Crock meter using cotton rubbing fabric. These results of both wet and dry rubbing fastness were correlated well under controlled conditions. The evaluation of the grade of fastness is done visually by using grey scale. The results were presented in the following tables. (Table 8 to 13).

Table 8. Fastness properties of cotton dyed by pre–simultaneous and post–mordanting method with *Hibiscus vitifolins* (Yellow portion)

Methods	Metal Salts	Rubbing Fastness		Light Fastness		
		Dry	Wet	8 hrs	12 hrs	16 hrs
	Dyed Fabric	4–5	4–5	7	6	6
	$CuSO_4$	4–5	3–4	7	7	6
	$FeSO_4$	4–5	3–4	7	7	6
	$NiSO_4$	3–4	2–3	7	6	5
	$K_2Cr_2O_7$	3–4	2–3	6	5	5
PRM	$SnCl_2$	4–5	3–4	7	6	5
	$Al_2(SO_4)_3$	4–5	3–4	7	6	6
	FAS	4–5	4–5	7	7	6
	NH_4Cl	4–5	3–4	7	6	6
	$ZnSO_4$	4–5	3–4	7	6	5
	$CuSO_4$	4–5	3–4	7	6	6
	$FeSO_4$	4–5	4–5	7	6	6
	$NiSO_4$	3–4	3–4	6	5	5
	$K_2Cr_2O_7$	3–4	2–3	6	5	4
SM	$SnCl_2$	4–5	3–4	7	6	5
	$Al_2(SO_4)_3$	4–5	3–4	6	5	4
	FAS	4–5	4–5	7	7	6
	NH_4Cl	4–5	3–4	7	6	5
	$ZnSO_4$	4–5	3–4	7	6	5
	$CuSO_4$	4–5	3–4	6	6	5
	$FeSO_4$	4–5	4–5	6	6	5
	$NiSO_4$	3–4	2–3	6	5	4
	$K_2Cr_2O_7$	3–4	2–3	5	4	3
POM	$SnCl_2$	4–5	3–4	6	5	5
	$Al_2(SO_4)_3$	3–4	2–3	6	5	4
	FAS	4–5	3–4	7	6	5
	NH_4Cl	4–5	3–4	6	5	5
	$ZnSO_4$	4–5	3–4	6	5	5

Table 9. Fastness properties of silk dyed by pre–simultaneous and post–mordanting method with *Hibiscus vitifolins* (Yellow portion)

Methods	Metal Salts	Rubbing Fastness		Light Fastness		
		Dry	Wet	8 hrs	12 hrs	16 hrs
	Dyed Fabric	3–4	3–4	7	6	6
	$CuSO_4$	4–5	3–4	6	5	5
	$FeSO_4$	4–5	4–5	7	7	6
	$NiSO_4$	4–5	2–3	6	6	5
	$K_2Cr_2O_7$	4–5	3–4	6	6	5
PRM	$SnCl_2$	4–5	3–4	7	7	6
	$Al_2(SO_4)_3$	4–5	4–5	7	7	6
	FAS	4–5	4–5	7	7	6
	NH_4Cl	4–5	3–4	7	7	6
	$ZnSO_4$	4–5	3–4	7	6	6
	$CuSO_4$	4–5	3–4	6	5	5
	$FeSO_4$	4–5	4–5	7	7	7
	$NiSO_4$	4–5	3–4	7	6	5
	$K_2Cr_2O_7$	3–4	2–3	6	5	5
SM	$SnCl_2$	4–5	3–4	7	7	6
	$Al_2(SO_4)_3$	4–5	3–4	7	7	6
	FAS	4–5	4–5	7	7	7
	NH_4Cl	4–5	3–4	7	7	6
	$ZnSO_4$	4–5	3–4	7	7	6
	$CuSO_4$	4–5	3–4	7	6	5
	$FeSO_4$	4–5	4–5	7	7	6
	$NiSO_4$	3–4	2–3	6	5	5
	$K_2Cr_2O_7$	3–4	2–3	5	4	4
POM	$SnCl_2$	4–5	3–4	7	7	6
	$Al_2(SO_4)_3$	4–5	3–4	7	6	5
	FAS	4–5	4–5	7	6	6
	NH_4Cl	4–5	3–4	7	6	5
	$ZnSO_4$	4–5	3–4	7	6	6

Table 10. Fastness properties of cotton dyed by pre–simultaneous and post–mordanting method with *Hibiscus vitifolins* (Brown portion)

Methods	Metal Salts	Rubbing Fastness		Light Fastness		
		Dry	Wet	8 hrs	12 hrs	16 hrs
	Dyed Fabric	3–4	2–3	5	4	4
	$CuSO_4$	4–5	3–4	7	6	5
	$FeSO_4$	4–5	3–4	7	7	6
	$NiSO_4$	3–4	2–3	6	5	5
	$K_2Cr_2O_7$	2–3	1–2	5	4	3
PRM	$SnCl_2$	4–5	3–4	6	5	5
	$Al_2(SO_4)_3$	4–5	3–4	6	5	4
	FAS	4–5	3–4	7	6	5
	NH_4Cl	4–5	2–3	6	5	5
	$ZnSO_4$	4–5	3–4	6	5	4
	$CuSO_4$	4–5	2–3	6	5	4
	$FeSO_4$	4–5	3–4	7	6	5
	$NiSO_4$	4–5	2–3	5	4	4
	$K_2Cr_2O_7$	3–4	2–3	5	4	3
SM	$SnCl_2$	4–5	3–4	6	5	5
	$Al_2(SO_4)_3$	4–5	3–4	6	5	5
	FAS	4–5	4–5	7	6	5
	NH_4Cl	3–4	2–3	5	4	4
	$ZnSO_4$	4–5	3–4	6	5	4
	$CuSO_4$	4–5	3–4	6	5	4
	$FeSO_4$	4–5	3–4	7	6	5
	$NiSO_4$	3–4	2–3	6	5	4
	$K_2Cr_2O_7$	3–4	1–2	5	4	3
POM	$SnCl_2$	3–4	2–3	6	5	4
	$Al_2(SO_4)_3$	4–5	2–3	5	4	3
	FAS	4–5	3–4	7	6	5
	NH_4Cl	3–4	2–3	6	5	4
	$ZnSO_4$	3–4	2–3	5	4	4

Table 11. Fastness properties of silk dyed by pre–simultaneous and post–mordanting method with *Hibiscus vitifolins* (Brown portion)

Methods	Metal Salts	Rubbing Fastness		Light Fastness		
		Dry	Wet	8 hrs	12 hrs	16 hrs
	Dyed Fabric	4–5	3–4	6	5	5
	$CuSO_4$	4–5	3–4	7	6	6
	$FeSO_4$	4–5	3–4	7	7	6
	$NiSO_4$	3–4	2–3	7	6	5
	$K_2Cr_2O_7$	3–4	2–3	6	5	5
PRM	$SnCl_2$	4–5	3–4	7	6	6
	$Al_2(SO_4)_3$	4–5	3–4	7	7	6
	FAS	4–5	4–5	7	7	6
	NH_4Cl	4–5	3–4	6	5	5
	$ZnSO_4$	4–5	3–4	6	6	5
	$CuSO_4$	4–5	4–5	7	6	5
	$FeSO_4$	4–5	3–4	7	7	6
	$NiSO_4$	4–5	3–4	6	6	5
	$K_2Cr_2O_7$	3–4	2–3	6	5	5
SM	$SnCl_2$	4–5	2–3	7	7	6
	$Al_2(SO_4)_3$	4–5	3–4	6	5	5
	FAS	4–5	4–5	7	7	6
	NH_4Cl	4–5	3–4	6	5	4
	$ZnSO_4$	4–5	2–3	6	5	4
	$CuSO_4$	3–4	2–3	6	5	4
	$FeSO_4$	4–5	3–4	7	7	6
	$NiSO_4$	3–4	2–3	6	5	5
	$K_2Cr_2O_7$	2–3	1–2	5	3	3
POM	$SnCl_2$	3–4	2–3	6	5	4
	$Al_2(SO_4)_3$	4–5	3–4	7	6	5
	FAS	4–5	4–5	7	7	6
	NH_4Cl	4–5	1–2	7	6	5
	$ZnSO_4$	4–5	3–4	6	5	4

Table 12. Fastness properties of cotton dyed by pre–simultaneous and post–mordanting method with *Sesbania aegyptiaca*

Methods	Metal Salts	Rubbing Fastness		Light Fastness		
		Dry	Wet	8 hrs	12 hrs	16 hrs
	Dyed Fabric	3–4	3–4	6	6	5
	$CuSO_4$	3–4	2–3	6	5	4
	$FeSO_4$	4–5	3–4	7	6	6
	$NiSO_4$	3–4	2–3	6	6	5
	$K_2Cr_2O_7$	3–4	2–3	5	4	4
PRM	$SnCl_2$	4–5	3–4	6	6	5
	$Al_2(SO_4)_3$	3–4	2–3	5	4	4
	FAS	4–5	4–5	7	6	5
	NH_4Cl	4–5	3–5	6	5	4
	$ZnSO_4$	3–4	2–3	6	5	5
	$CuSO_4$	3–4	2–3	5	4	4
	$FeSO_4$	4–5	4–5	6	5	4
	$NiSO_4$	3–4	2–3	5	4	3
	$K_2Cr_2O_7$	2–3	2–3	4	3	3
SM	$SnCl_2$	4–5	3–4	6	5	4
	$Al_2(SO_4)_3$	3–4	2–3	5	4	3
	FAS	4–5	3–4	6	5	5
	NH_4Cl	4–5	3–4	6	5	5
	$ZnSO_4$	3–4	2–3	5	5	4
	$CuSO_4$	3–4	2–3	6	5	4
	$FeSO_4$	4–5	4–5	6	5	4
	$NiSO_4$	3–4	2–3	5	4	3
	$K_2Cr_2O_7$	3–4	2–3	5	4	3
POM	$SnCl_2$	4–5	3–4	6	5	4
	$Al_2(SO_4)_3$	3–4	2–3	5	4	4
	FAS	3–4	2–3	6	5	4
	NH_4Cl	3–4	2–3	5	4	3
	$ZnSO_4$	3–4	3–4	5	4	4

Table 13. Fastness properties of silk dyed by pre–simultaneous and post–mordanting method with *Sesbania aegyptiaca*

Methods	Metal Salts	Rubbing Fastness		Light Fastness		
		Dry	Wet	8 hrs	12 hrs	16 hrs
	Dyed Fabric	4–5	4–5	7	6	5
	$CuSO_4$	4–5	4–5	7	6	5
	$FeSO_4$	4–5	4–5	7	6	6
	$NiSO_4$	3–4	2–3	6	6	5
	$K_2Cr_2O_7$	4–5	3–4	7	6	5
PRM	$SnCl_2$	4–5	3–4	6	5	5
	$Al_2(SO_4)_3$	4–5	3–4	6	5	5
	FAS	4–5	4–5	7	6	5
	NH_4Cl	3–4	2–3	6	5	4
	$ZnSO_4$	4–5	3–4	7	6	5
	$CuSO_4$	4–5	4–5	7	6	6
	$FeSO_4$	4–5	4–5	7	7	6
	$NiSO_4$	3–4	2–3	6	5	5
	$K_2Cr_2O_7$	3–4	2–3	7	6	5
SM	$SnCl_2$	4–5	3–4	6	6	5
	$Al_2(SO_4)_3$	4–5	3–4	6	6	5
	FAS	4–5	3–4	7	7	6
	NH_4Cl	4–5	3–4	6	5	4
	$ZnSO_4$	4–5	3–4	6	5	5
	$CuSO_4$	4–5	3.4	5	5	4
	$FeSO_4$	4–5	4–5	7	6	5
	$NiSO_4$	3–4	2–3	6	5	4
	$K_2Cr_2O_7$	4–5	3–4	6	5	5
POM	$SnCl_2$	4–5	3–4	6	5	5
	$Al_2(SO_4)_3$	3–4	2–3	5	5	4
	FAS	4–5	3–4	6	6	5
	NH_4Cl	3–4	2–3	6	5	5
	$ZnSO_4$	3–4	2–3	5	4	4

Rubbing Fastness: 1–Very poor; 2–Poor; 2–3–Moderate; 3–4 – Fair; 4 – Good; 4–5 – Very good; 5 – Excellent
Light Fastness : 3 – Poor; 4 – Moderate; 5 – Fair; 6 – Good; 7 – Very good; 8 – Excellent

Light fastness : The light fastness of the dyed samples were assessed by exposing the dyed samples to the sunlight for 8, 12 and 16 hours and then extent of fading was assessed and gradings were given. The results were presented in the following tables. (Tables 8 to 13).

CONCLUSION

These dye extracts produce excellent colours and hues on cotton and silk fabrics with or without metal salts. All the well known methods of dyeing – pre–mordanting, simultaneous mrodanting and post–mordanting have been tried on these fabrics. They have yielded appreciable results.

The samples have shown good light fastness and rubbing fastness characteristics in most samples. The samples show poor light and rubbing fastness properties, when dyed with Cr (VI), Ni (II) and Sn (II) ions.

Both classes of dye extracts failed to produce any colour with bleached wool fabric.

The exact molecular structure of these dye substances could be unraveled by employing instrumental methods such as UV, IR, ^{1}H NMR, ^{13}C NMR, Gas Chromatography (GC) and Mass Spectrometry (MS). Such a study would throw more light on the exact nature of the molecules. This would further facilitate the research study to utilise these substances extensively to all kinds of yarns and fabrics. A step in this direction would lead to the long march in achieving large–scale preparation of natural dyes.

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