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Value-added simultaneous dyeing and finishing of viscose using natural resources

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Abstract

The extensive utilization of the synthetic dyestuffs for the colouration of various textiles has been disparaged owing to the introduction of contamination into the environment. The application of dyestuffs derived from the natural resources, in textile wet processing for dyeing and printing of textiles, is an environmental-friendly approach for the protection of the biosphere. Today, it is noteworthy that people worldwide have started accepting the fact that natural dyes are the most traditional and hygienic. Vegetable natural dyestuffs are very good for skin and soothing to eyes. In the present work, a natural vegetable dye, extracted from Hibiscus rosa-sinensis flower, has been used for the dyeing of a regenerated cellulosic fibre, viscose rayon. The dyeing has been performed on the fabric pre-mordanted with a tannin-based natural mordant, viz. myrobolan. Padding techniques have been adopted for mordanting and dyeing. The effect of the mordant on the shade, tone, colour strength (K/S) values and various fastness properties has been studied for the natural colour dyed viscose samples. In the modification of the dyeing process, simultaneous finishing treatment was also carried out by addition of the Aloe vera extract to the dyeing liquor and performing simultaneous dyeing and finishing by the same procedures as utilized for dyeing alone. Performance of aloe vera for enrichment of the comfort characteristics of the dyed substrate has been evaluated. The performance of dyeing and finishing operations in the single bath leads to considerable saving of energy, water, labour, time and cost. Moreover, utilization of natural resources for mordanting, dyeing and finishing makes the approach a "Green technological approach".

Keywords: Viscose rayon, Flower extract, Tannin-based mordant, Aloe vera, Dyeing and Finishing, Fastness and Comfort characteristics.

Introduction

Textile industry is highly prone to pollution due to the wide varieties of dyes, chemicals and auxiliaries involved in the chemical wet processing of textiles leading to generation of enormous amount of effluent. Environment awareness has diverted the attention of the textile chemist towards utilization of natural resources against comparatively more harmful synthetic dyes and chemicals. With the world becoming more cognizant towards preservation of the precious bionetwork and environment, there is greater necessity nowadays to resuscitate the practice of dyeing with natural dyes as an alternative of the perilous synthetic dyes. Today, as the people are becoming more towards their health, the utilization of natural dyes, particularly vegetable based natural dyes, is gaining importance since they are more hygienic, good for skin, soothing to eyes and do not impose any harmful effect on the ecosystem. The natural dye component present in plants and animals exist in the state of coloured pigments, which impart colour to the textile substrates[1]. In case of plants, several parts of various plants contain colouring components, which provide natural dyes to be used for dyeing and printing of textiles. However, the common shortcomings of natural dyes are associated with their lack of reproducibility, consistency and uniformity of shades, adequate colour fastness and deficiency of availability of any scientific evidence on the chemistry of dyeing as well as standardized techniques of dyeing[2-4].

Characteristically, natural dyes have wide variety, renewable, non-toxic, non-carcinogenic, nonpoisonous, biodegradable, and non-hazardous to life[5,6]. Natural dyes enhance aesthetic properties[7]and are innocuous from ecological point of view[8]. They also offer monetary benefits through sustainable produce of the dye bearing plants[5]; their commercialization can lead to the improvement of the economy of the country[9].

Textile dyeing and functional finishing are two necessary and traditional separate processes employed in the chemical wet processing of textiles. Simultaneous dyeing and finishing in one bath could reduce both the cost of production and consumption of resources. The main purpose of utilizing natural products was to produce wellness textile, substantial saving of water, time, labour, chemicals and energy by jointly performing dyeing and finishing operations and minimization of effluent load due to utilization of natural resources and combining two processes into one.

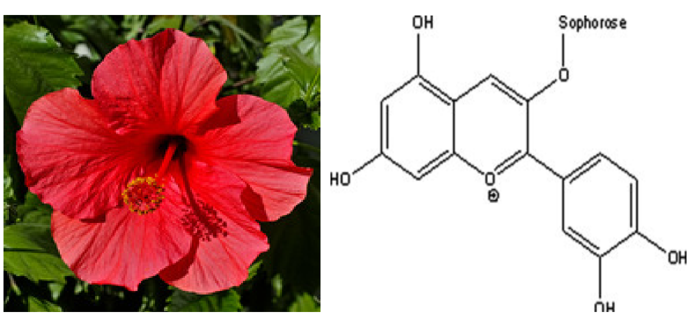
In the present work, two natural plant product have been used for producing wellness textiles with improved performance and high aesthetic significance. The natural dye used in this research work is extracted from China rose (*Hibiscusrosa-sinensis*) flower which is also the herbal dye. The flowers is anodyne, emmenagogue, and used in the treatment of women's complaints. They regulate menstruation and stimulate blood circulation. The natural finishing agent, Aloe vera has antifungal and antibacterial properties, which can be exploited for medical textile application, such as wound dressing, suture, and bioactive textiles. The application of these two natural products was performed on a regenerated cellulosic fibre, viscose. A mordant, myrobolan has been selected for pre-mordanting of viscose rayon, on which *Hibiscus rosa sinensis* and aloe vera extracts have been applied by padding technique. Utilization of natural resources for mordanting, dyeing and finishing by no-effluent generating padding techniques may be considered as an innovative step towards green sustainable environment.

Materials and methods

Materials: Fabrics: A plain weave viscose fabric having the following specifications was used for the study: i. Warp: 44 ends/inch; ii. Weft: 36 picks/inch; iii. Weight: 149 g/m^2.

Grey viscose fabric was procured from Birla Cellulose Division, Kosamba. The fabric was scoured with 5 gpl non-ionic detergent (Lissapol N) and 5 gpl soda ash at boil for 90 min. The scoured fabric was then bleached with sodium hypochlorite (5 gpl available chlorine) using pH 10 at room temperature for 1 hour and subsequently washed thoroughly till it became neutral.

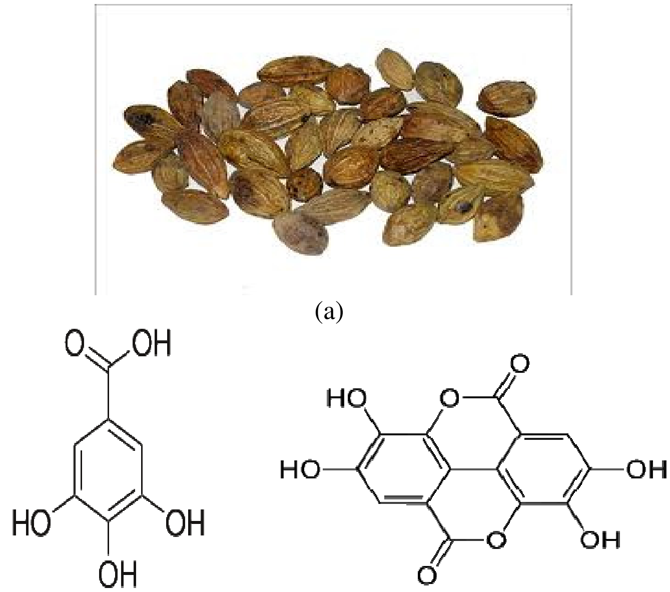
Natural Products: Dyestuff: The natural dye selected for the investigation was extracted from the china rose (*Hibiscus rosa-sinensis*) flowers (Figure-1a). Pink and red varieties of *Hibiscus rosa-sinensis* are common Hibiscus flower in India. The flowers are used to shine shoes in many parts of India. In Indonesia, these flowers are basically termed as "*kembang sepatu*", which factually means "shoe flower". The variety of *Hibiscus rosa sinensis* selected for the present study was having five red coloured petals. The colouring component present was anthocyanin, namelycyanidin-3-sophoroside (Figure-1b)[10,11].



(a) (b)

Figure-1: (a) A typical hibiscus flower, (b) Cyanidin-3-sophoroside pigment.

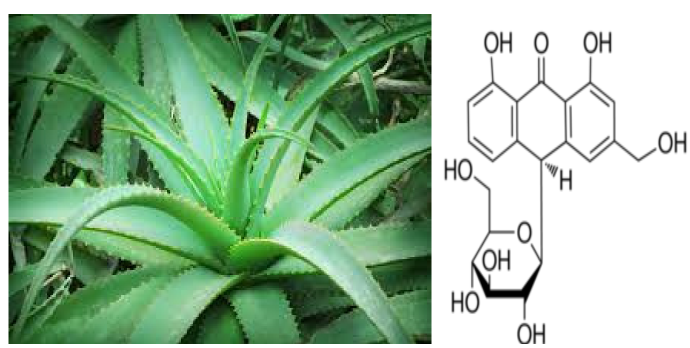
Mordant: A tannin-rich mordant, Myrobolan (Figure-2a) was selected for the present study. Myrobalan is the fruit of trees such as *Terminalia Chebula* and *Myrobolanus Chebula*[12]. It is hydrolysable by mineral acids or enzymes such as tannase. Its structures involve several molecules of polyphenolic acids such as gallic, hexahydrodiphenic or ellagic acids (Figures-2b and 2c), bounded through ester linkages to a central glucose molecule. The myrobalan fruit was procured from the local market of Vadodara.



(b) (c)

Figure-2: (a) Myrobolan mordant, (b) Gallic acid, and (c) Ellagic acid.

Aloe vera: A natural product, namely Aloe vera (Figure-3a) was used as a finishing agent for imparting aesthetic characterisitcs to the viscose substrate. The active component in aloe vera is Aloin (Figure-3b), which possess antimicrobial and other wellness characteristics[13-15]. Aloe vera leaves and its gel contain many biologically active compounds, such as anthraquinones, several lectins, salicylic acid and acetylated mannans and various enzymes. Anthraquinones (Aloin, anthracene, emodin, etc.) and salicylic acid are mainly responsible for providing antimicrobial properties to aloe vera against bacteria, fungus and other micro-organisms.



(a) (b)

Figure-3: (a) Aloe vera plant, (b) Structure of Aloin component.

Chemicals and auxiliaries: A thickener, sodium alginate and a natural detergent were procured from Rasayan trading company, Ahmedabad.

Experimental methods: Preparation of the dye solution: The colouring pigment, anthocyanins from Hibiscus flowers, has been extracted with methanol in presence of citric acid. The dried petals of the flower were treated with 4.0% citric acid (w/v) in methanol for 2 hat room temperature in dark without stirring. The mixture was filtered and the remaining solids were washed with 4.0% citric acid in methanol until a clear solution was obtained. Methanol was evaporated in a rotary evaporator, the content was dried and dissolved in water and the solution was used for dyeing purpose[16-17].

Extraction of aloe vera: The fully expanded leaves of aloe vera were selected from the plant and washed with water. On cutting, an orange yellow sap drips from the open end of the leaf. The inner transparent gel is carefully removed while avoiding the yellow sap (latex) to mix with it. The gel was transferred from the leaves into a clean beaker and homogenized in a blender at 30 rpm. The homogenized gel was then dried in the oven at 75°C for about two days and then grinded into fine powder form. The powder was then subjected to soxhlet extraction method. 50g of the powder was soxhlet extracted with 250 ml of methanol at 70°C for 12 hours. The extract was slowly evaporated to dryness using a rotary evaporation to yield dry powder of aloe vera gel, which is stored in an air-tight glass bottle at room temperature[18].

Mordanting and dyeing procedures: Mordanting: The myrobolan mordant was applied on the viscose material by using pre-mordanting technique[3,19], in which the textile material is first treated with the mordant and then dyed. Intermediate drying allows storage of the mordanted material and helps in absorption of the dye liquor.

Pad (Mordant) – Dry – Pad (Dye) – Dry – Cure

In the pre-mordanting procedure, the fabric was treated with 20 gpl myrobolan on a 2 bowl padding mangle using 65 % padding expression and 3-dip-3-nip padding technique. The concentration of myrobolan was optimized separately by chosing different concentrations of myrobolan, ranging from 2 gpl to 30 gpl, and the optimum concentration of the mordant was selected from the subsequent dyeing performance of *Hibiscus rosa-sinensis* on the mordanted samples adjudged from their colour strength values, in terms of K/S values, evaluated spectrophotometrically.

Dyeing: The mordanted fabric sample was padded with the Hibiscus– aloe vera solution (10 – 100 gpl Hibiscus dye, 20gpl aloe vera extract, 1 gpl sodium alginate and requisite amount of soda ash for maintaining the pH of about 8.5) at room temperature, dried using ambient conditions and then cured at 150˚C for 5 minutes in dry heat (oven) for fixation of the dye after padding. The curing conditions were so selected as these conditions, namely temperature and time of curing are commercially practiced for dyeing of various classes of dyestuffs on cotton materials. Sodium alginate served as an anti-migrant to prevent the two-sided effect, while sodium carbonate (soda ash) was use to maintain the pH in the range of 8.5. After curing, the dyed samples were washed off (soaped) with 2 gpl natural detergent solution at 50°C for 20 minutes using liquor ratio of 50:1. This was followed by consecutive rinsing in hot and cold water respectively, and finally the fabric was dried under ambient conditions.

Testing and Analysis: Evaluation of colour strength of dyed samples: For evaluation of the colour strength of the dyed as well as simultaneously dyed and finished viscose rayon sample, the colour strength (in terms of *K/S*) value of the dyed sample was determined by computing surface reflectance of the samples on a spectrophotometer with 10° observer using D65 illuminant[20]. An average of three measurements of colour strength (K/S) or reflectance was recorded with the help of relevant software. The colour measurement was done by Spectrophotometer interphased with computer colour matching system; Spectra scan 5100 (RT) (Premier colour scan instrument), India. Colour measurement is based on the ratio between total light absorbed (K) and scattered (S) by the substrate as defined by the Kubelka-Munk equation[21] given as

$$K/S = (1-R)^2/2R$$

Where: K is the absorption coefficient, S is scattering coefficient, and R is the value of reflectance measured at a given wavelength.

Measurement of fastness properties: The dyed samples were evaluated for their fastness characteristics towards numerous agencies like washing, light and rubbing using standard procedures[22] as stated below:

Determination of fastness to washing: The washing fastness of various dyed and finished samples was evaluated on a Launder-o-meter using ISO standard Test No. 3 (ISO 105-C03:1989). After the treatment procedure, the change in shade was envisaged using Grey scale and categorized from 1 to 5; where 1 designates poor and 5 excellent fastness to washing.

Determination of fastness to light: Colour fastness to light was assessed by exposing the dyed samples to sunlight according to AATCC test method 16-2004. They were graded from 1 to 8; where 1 specifies poor and 8 excellent fastness to light.

Determination of fastness to wet and dry rubbing: The fastness to crocking (rubbing) of dyed samples was tested on Crockmeter utilizing AATCC 8-2007 test method. The specimen to be tested was rubbed against perfectly scoured and bleached cloth of dimension not less than 22 cm x 5 cm. The white rubbing cloth was positioned over the end of the finger of the testing device. Two specimens were used, one each for dry and wet rubbing test. For the determination of dry rub fastness, the sample to be tested was rubbed 10 times in 10 seconds in a dry condition; whereas for wet rub fastness determination, same procedure has been adopted by wetting out the rubbing cloth and squeezing it to 100 % expression. The intensity of stain obtained on white fabric as well as decrease in the shade-depth of the rubbed sample were considered for assigning the grades to the tested samples. The staining on the rubbing cloth was assessed with the Grey Scale and grades awarded from 1 to 5, where 1 stands for poor and 5 for excellent fastness to rubbing.

Determination of wear comfort characteristics: Comfort is possibly characterized amongst the most multifaceted physiognomies of clothing. Wear comfort is one of the utmost important perception in context to textiles, particularly related to garments and clothing. Various test were performed in the present study to assess the wear comfort characteristics of the viscose dyed and finished substrate[23–25].

Evaluation of wettability (AATCC 79-2000): Wettability is precisely defined as the time taken (in seconds) for a drop of water to sink into the fabric. The test is usually done by Drop test method. The test specimen is clamped onto an embroidery frame of 150 mm diameter so that it is held taut and away from any surface. A burette with a standard tip size (specified in the standard) is clamped 6mm above the horizontal surface of the sample. A drop of water is allowed to fall on to the fabric and the time taken for it to sink into the fabric is measured under standard condition.

Air permeability test (ASTM D 737-96): Air permeability is a measure of how easily air can pass through a material. This characteristic of the fabric is principally based on the density and the structure of the material. The air permeability of treated and untreated fabric samples was measured on Metefem air permeability tester using standard ASTM D 737-96 test method for the mordanted and dyed as well as modanted, dyed and finished viscose substrates. Five specimens were used each with a test area of 508 mm^2 (25.4 mm diameter) and an average air flow in ml/sec was calculated from the readings. The value was further used to calculate the air permeability in ml per 100 mm^2 per second.

Stiffness test (AATCC 115-2005): A bending test decides the severity of the flexing action of a material and also gives an idea about the effect of the treatment on softness of the fabric. The test was performed on Shirley stiffness tester using standard test method AATCC 115-2005; the bending length of the sample was measured on the instrument. The bending length, also known as the drape stiffness, is dependent on the weight of the fabric and is, therefore, a vital component of the drape of the fabric when it is allowed to hang under its own weight. In the test, a horizontal strip of fabric is clamped at one end and the rest of the strip is allowed to hang under its own weight, when it will bend under its own mass to an angle of 7.1°. This property can influence the aesthetic appearance as well as the comfort of a fabric.

The test specimen (25 mm x 200 mm), in a flat state, is preconditioned for 4h (5O°C and 10% R. H.) and then conditioned for 24 h. Four readings are taken from each specimen, one face up and one face down on the first end, and then the same for the second end. The average bending length for warp and weft is calculated. The higher the bending length, the stiffer is the fabric[24,25].

Crease recovery angle test (AATCC 66-2003): Cellulosic materials like cotton, viscose, linen, etc. exhibit poor resistance to creasing. The measurements were done on Shirley crease recovery tester. During the test, a rectangular fabric sample (44 mm x 15 mm) is folded and then placed under a 10 N load for 5 min to form a crease. It is immediately transferred to the holder of the measuring instrument and is allowed to recover for a specific time and the angle of the crease that remains is measured. The extent of this crease recovery angle is an indication of the capability of a fabric to improve from unintentional creasing.

Abrasion resistance test (ASTM D 4966): Fabrics are endangered to abrasion during their lifetimes and this may consequence in wear, deterioration, damage and a loss of performance. The test for abrasion resistance was performed on Abrasion resistant tester (Henay baer and Co. Zurich). A sample (10 cm x 10 cm) is mounted on specimen holder and the holder is fit by screw. The fabric is subjected to the wear action by abrasive wheels. The specimen holder lay down and pressed using a known weight onto a wheel. The wheel moves forward and reverse in one cycle and the fabrics starts getting abraded. The abrasion continues until damage occurs, the specimen holder comes down and machine stops automatically. The assessment of abrasion is done from the number of cycles of the abrader required for the rupture in the structure of fabric.

Evaluation of fabric thickness (ASTM D1777): The thickness of a fabric is one of its basic properties, giving information on its warmth, weight and stiffness. Thickness is also concomitant with the aesthetics and comfort characteristics of the fabric. Thickness measurements are very sensitive to the pressure. In practice, fabric mass per unit area is often used as an indicator of thickness.

The measurement of thickness of fabric samples in laboratory is customarily performed on a Precision thickness tester (Mitutoyo, Japan). In this equipment, the fabric whose thickness is to be determined is kept on a flat anvil and a circular pressure foot is pressed onto it from the top under a standard fixed load. The dial Indicator directly gives the thickness of the fabric in mm.

Results and discussion

The dyeing of *Hibiscus rosa sinensis* dye was conducted on myrobolan pre-mordanted cotton samples and the dyeing performance was observed in terms of variation of shade and fastness characteristics of the dyed samples. The unmordanted sample was dyed in the pinkish shade at lower concentration of the dye and light brown to dark brown shades at higher concentrations of the dye. On the other hand, mordanting with myrobolan tannin changed the shade from purplish to brownish side at different concentrations of the dye in the dye bath. The experiments were further extended for performing simultaneous dyeing with Hibiscus dye and finishing with aloe vera finishing agent. Various wear comfort properties of the dyed and finished samples have been assessed. The preparation of shade card with viscose rayon dyed in the presence and absence of aloe vera has been studied to visualize the viability of the simultaneous dyeing and finishing process.

Effect of mordant on the dyeing performance: Colour strength of the dyed samples: The effect of myrobolan mordant can be easily visualized from the colour strength values of various dyed samples mentioned in Table-1. It can be seen from the Table that there is substantial improvement in the colour strength (in terms of K/S) values.

Standard *K/S* value of dyeing with hibiscus dye alone on viscose fabric is same or nearer to the dyeing with hibiscus dye in conjunction with natural finishing agent, aloe vera. This implies that the utilization of finishing agent in the dyeing liquor does not alter the colour strength value and the tone of the shade also remains the same. Therefore, simultaneous dyeing and finishing can be performed without affecting the dyeing performance. Moreover, as the concentration of the dye in the dyeing bath increases, there is gradual increase in the colour value as depicted from the *K/S* values. Hence shade cards can be prepared with ease.

Shades of the dyed and finished samples: The shade of the dyed samples also changes when the mordanting with myrobolan mordant is done. However, the shade is not much changed further when dyeing is performed on the mordanted samples in the presence of aloe vera finishing agent. The change in the tone of the shades for some samples is represented in Table-2. In case of unmordanted viscose rayon, pinkish shades are obtained at lower concentration of the dye which changes to brick red and brown shades with an increase in the concentration of the dye in the dyebath. The results obtained are nearly similar when aloe vera is added to the dyebath and the dyeing and finishing are carried out simultaneously on unmordanted samples. However, when the dyeing as well as simultaneous dyeing and finishing are performed on myrobolan mordanted sample, the shades varied from light purple to dark brown at different concentrations of the dye in the dye bath.

Fastness characteristics of the dyed and finished samples: The fastness characteristics (wash, light and rub) of dyed samples are quite adequate, irrespective of whether the sample is dyed with hibiscus dye in presence or absence of aloe vera finishing agent. Table-3 demonstrates the various fastness properties (wash, light and dry/wet rub) of some unmordanted and dyed/dyed and finished as well as viscose sample mordanted with myrobolan mordant and subsequently dyed/ dyed and finished with hibiscus rosa sinensis dye and aloe vera finishing agent. In the table, fastness properties for 3 different concentrations of the dye has been shown. At other concentrations also, similar performance has been exhibited by various samples. The finishing agent also does not alter the fastness characteristic of the dyed substrate and hence simultaneous dyeing and finishing can be adopted on commercial scale.

Table-1: Colour strength values of the unmordanted and mordanted dyed as well as dyed and finished samples.

Dye conc. (gpl)	Colour strength (K/S) values of viscose sample			
	Without mordanting		With mordanting	
	Dyed with hibiscus dye alone	Dyed with hibiscus dye in presence of aloe vera	Dyed with hibiscus dye alone	Dyed with hibiscus dye in presence of aloe vera
10	2.67	2.83	3.49	3.57
20	3.95	4.12	5.82	5.97
30	5.22	5.46	8.23	8.65
50	8.46	8.69	11.77	11.96
80	13.79	14.05	16.43	16.48
100	21.48	22.44	25.68	25.79

Table 2: Effect of myrobolan mordant on the shades of viscose fabric dyed and finished with hibiscus dye and aloe vera finishing agent.

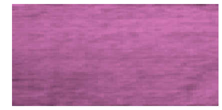
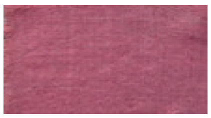
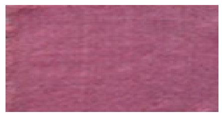
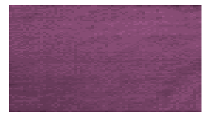
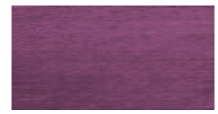
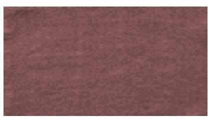
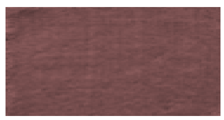
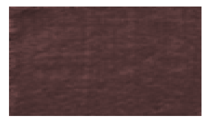
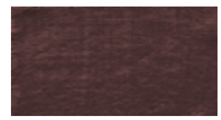
Dye conc. (gpl)	Shades of viscose sample			
	Without mordanting		Pre-mordanting with Myrobolan	
	Dyed with hibiscus dye alone	Dyed with hibiscus dye in presence of aloe vera	Dyed with hibiscus dye alone	Dyed with hibiscus dye in presence of aloe vera
10				
50				
100				

Table-3: Fastness grades of various mordanted and unmordanted dyed and finished samples.

Dye conc. (gpl)	Fastness grades of viscose sample															
	Without mordanting								With mordanting							
	Dyed with hibiscus dye alone				Dyed with hibiscus dye in presence of aloe vera				Dyed with hibiscus dye alone				Dyed with hibiscus dye in presence of aloe vera			
	W	L	R		W	L	R		W	L	R		W	L	R	
			Dry	Wet			Dry	Wet			Dry	Wet			Dry	Wet
10	4	6	4	4-5	3-4	7	4-5	4-5	5	6-7	4-5	5	4-5	7	5	4-5
50	3-4	6	4	5	3-4	6-7	4-5	4	4-5	6-7	4	5	5	6-7	5	4-5
100	4	6-7	4	4	4	6-7	4-5	4-5	4-5	7	4-5	4-5	5	6-7	4-5	4-5

W: Wash fastness, L: Light fastness, R: Rub fastness.

Effect of finishing agent during simultaneous dyeing and finishing on the comfort properties of viscose rayon: Wear comfort tests were performed for viscose fabric dyed with hibiscus dye at 1%, 5% and 10% shades (corresponding to 10, 50 and 100 gpl dye concentrations respectively), either alone as well as in combination with aloe vera finishing agent. Various wear comfort examined during the present investigation were wettability, air permeability, stiffness, crease recovery angle, abrasion resistance and fabric thickness measurement.

The respective values of these characteristics are mentioned in Table-4. Studies based on other advanced wear comfort properties, such as measurement of UV protection factor (UPF), antimicrobial resistance and related hygienic properties are under progress.

The absorbency of water by the treated and untreated fabric using Drop test method is mentioned in Table-4. It can be visualized from the table that there is no significant change in the absorbency time recorded for the viscose fabric dyed with hibiscus flower dye on unmordanted as well as mordanted substrates. However, when the dyeing was performed in presence of the aloe vera finishing agent, the values of water drop being absorbed by the mordanted as well as unmordanted and dyed viscose substrate are slightly higher than the unfinished samples, which shows that finishing agent aloe vera reduce the absorbency of the fabric slightly. However, the values are only marginally higher, thereby keeping the fabric in absorbent state even after the finishing application. The difference is so minute that for practical application purpose, in the present study, it can be said that wettability remains almost same as parent sample after simultaneous dyeing and finishing.

Further, it may also be visualized from the Table-4 that the viscose fabric dyed with natural hibiscus dye has slight influence on the air permeability. Incorporation of finishing agent aloe vera in the dyebath further decreases the value of air permeability slightly. The possible reason for such behavior may be that the air holes of the fabric were slightly blocked with the natural dye and aloe vera finishing agent.

Table-4: Various comfort properties of untreated, mordanted and unmordanted viscose sample dyed with hibiscus flower dye in presence and absence of aloe vera finishing agent.

Dye conc. (gpl)	Various comfort characteristics of viscose sample			
	Without mordanting		With mordanting	
	Dyed with hibiscus dye alone	Dyed with hibiscus dye in presence of aloe vera	Dyed with hibiscus dye alone	Dyed with hibiscus dye in presence of aloe vera
	Wettability (in seconds) for viscose fabric (Wettability for undyed parent sample = 2.67 sec).			
10	2.72	3.12	2.76	3.26
50	2.77	3.15	2.75	3.29
100	2.75	3.22	2.75	3.36
	Air permeability (in $m^3/m^2/h$) for viscose fabric (Air permeability for undyed parent sample = 2959 $m^3/m^2/h$).			
10	2918	2902	2916	2899
50	2904	2888	2894	2872
100	2892	2875	2887	2869
	Bending length (in cm) for viscose fabric (Bending length for undyed parent sample = 2.2 cm).			
10	2.1	2.0	2.1	1.9
50	2.0	1.9	2.1	1.9
100	2.0	1.9	1.9	1.7
	Crease recovery (in ^{o}) for viscose fabric (Crease recovery for undyed parent sample = 92^o).			
10	91	105	90	107
50	94	108	93	109
100	96	112	94	110
	Abrasion resistance (in number of cycles) for viscose fabric (Abrasion resistance for undyed parent sample = 54).			
10	53	56	52	55
50	54	58	54	57
100	54	56	53	57
	Fabric thickness (in mm) for viscose fabric (Fabric thickness for undyed parent sample = 0.39 mm).			
10	0.40	0.42	0.41	0.43
50	0.41	0.43	0.41	0.43
100	0.41	0.43	0.41	0.44

It is found that when viscose fabric is dyed with hibiscus dye alone, the bending length values are quite similar to that of undyed parent sample; but incorporation of aloe vera finishing agent in the dyeing liquors decreases the bending length of the dyed and finished samples substantially, thereby indicating the improvement in the smoothness of the fabric. Lower value of bending rigidity supports the positive sense of sensorial comfort.

Viscose, being a cellulosic fibre, is highly prone to the creasing effect. The fabric dyed alone with hibiscus dye shows the crease recovery value similar to that of undyed parent sample; however, when the viscose fabric is dyed with hibiscus dye in the presence of aloe vera finishing agent in the same bath, there is a significant improvement in the value of crease recovery angle. Thus, treatment with aloe vera not only provides smoothness to the substrate but also increases the crease resistance power of the fibre.

Viscose substrate possesses adequate abrasion resistance. However, there is not much improvement in the abrasion resistance of the substrate whether the application of hibiscus dye is performed in the presence or absence of aloe vera finishing.

The thickness of textile material is one of its basic properties which give important information regarding warmth, heaviness or stiffness during use. The results from Table-4 exhibit an enhancement in the fabric thickness from 2 to 13% for viscose fabric irrespective of whether they are dyed with the hibiscus natural dye in presence or absence of finishing agent.

Conclusion

The chemical wet processing of textiles is prone to environmental pollution due to large amount of hazardous dyestuffs and chemicals being utilized for conducting different processes. Therefore, in the present scenario of awareness towards preservation of environment and also health problems associated with wearing of chemically intensified textiles, utilization of natural resources for colouration and finishing of textiles can be considered as a safe and environmental-friendly perception. Further, the two processes of dyeing and finishing have been unified into a single stage process, thereby leading to considerable saving of water, energy, time, labour and chemicals. Simultaneous performing of dyeing and finishing in one bath reduces both the cost of production and consumption of valuable resources. The natural functional finishing agent, aloe vera, was so selected that its incorporation into the dyeing bath does not affect the dyeing behaviour of hibiscus rosa-sinensis natural dye. The application of various processes, viz. mordanting, dyeing as well as combined dyeing and finishing were carried out using padding (pad-dry-cure) technique on a regenerated cellulosic fibre, viscose rayon. The use of pad-dry-cure technique is considerably efficient than exhaust dyeing because large amount of water and chemicals can be saved by its use. The use of natural resources, combination of two separate processes into one and utilization of padding technique for dyeing is also supposed to have minimization of effluent treatment. The dyeing results on mordanted viscose rayon were quite encouraging even in the presence of aloe vera finishing agent. The dyed and finished fabrics had satisfactory fastness to washing, light and rubbing. The myrobolan mordant utilization has an influence on the shade of the dyed and finished samples. All the simultaneously dyed and finished samples exhibit good wear comfort properties than the parent samples. The modified process used in the investigation can be considered as a step towards a sustainable 'Green environmental technology".

References

1. Bains S., Singh O.P., Goraya G. and Kang M. (2003). Dyeing of Cotton with Golden drop dye. Journal of the Textile Association, 64(4), 183-186.

2. Samanta A.K., Singhee D. and Sethia M. (2003). Application of single and mixture of selected natural dyes on cotton fabric: A scientific approach. *Colourage*, 50(10), 29-42.

3. Gulrajani M.L. and Gupta D. (1992). Natural dye and their application to textiles. Department of Textile Technology, IIT, Delhi.

4. Agrawal B.J. and Patel B.H. (2000). The reincarnation of natural colourants–a review. *Chemical Weekly*, 45(38), 139-146.

5. Saravanan P., Chandramohan G., Mariajancyrani J. and Kiruthikajothi K. (2014). Ecofriendly dyeing of cotton fabric with a natural dye extracted from flowers of Lantana camara Linn. *International Journal of Bioasays*, 3(1), 1653-1656.

6. Thiyagarajan S, Balakrishnan K. and Tamilarasi S. (2015). A study of extraction and dyeing behavior of natural dye obtained from cotton A Study. *IOSR Journal of Applied Chemistry*, 8(5), 85-89.

7. Vankar P.S. (2007). Handbook on Natural Dyes for Industrial Applications. *National Institute of Industrial Research*.

8. Mahanta D. and Tiwari S.C. (2005). Natural dye-yielding plants and indigenous knowledge on dye preparation in Arunachal Pradesh, northeast India. *Current science*, 88(9), 1474-1480.

9. Upadhyay R. and Choudhary M.S. (2014). Tree bark as a source of natural dyes from the forests of Madhya Pradesh. *Global Journal of Bio-Science and Biotechnology*, 3(1), 97-99.

10. Ali M. and Ansari S.H. (1997). Hair care and herbal drugs. *Indian Journal of Natural Products*, 13, 3-5.

11. Singh M.P., Singh R.H. and Udupa K.N. (1982). Antifertility activity of a benzene extract of Hibiscus rosa sinensis flowers in female albino rats. *Planta Medica*, 44(3), 171-174.

12. Mudgal S. and Mahale G. (2002). Fountain flower dyed UAS sheep breed wool - Its colour fastness in acidic media. *Man Made Textiles in India*, 45(4), 149-152.

13. Jasso de Rodríguez D., Hernández-Castillo D., Rodriguez-Garcia R. and Angulo-Sanchez J.L. (2005). Antifungal activity in vitro of Aloe vera pulp and liquid fraction against plan pathogenic fungi. *Industrial Crops andProducts*, 21, 81-87.

14. Hamman J.H. (2008). Composition and Applications of Aloe vera Leaf Gel. *Molecules*, 13(8), 1599-1616.

15. Kan C.W. and Yuen C.W.M. (2005). Cosmetic textiles. *Textile Asia*, 36(6), 29-35.

16. Ramprasath R., Kavi G.G. and Rathi T.S. (2017). Isolation of natural dyes from hibiscus rosa sinensis and marigold flower and dyeing properties of the dyes on cotton cloth. *IOSR Journal of Applied Chemistry*, 10(5), 74-79.

17. Vankar P.S. and Shukla D. (2011). Natural dyeing with anthocyanins from Hibiscus rosa sinensis flowers. *Journal of Applied Polymer Science*, 122(5), 3361-3368.

18. Khan A.F. (2012). Extraction, stabilization and application of antimicrobial agents from Aloe vera. *Pakistan Textile Journal: Dyeing Printing Finishing*, 42-44.

19. Samanta A.K. and Konar A. (2011). Dyeing of textiles with natural dyes (Chapter 3). In *Naturaldyes*, Edited by E. Perrin Akçakoca Kumbasar. Publisher: InTech.

20. Billmeyer F.W. and Saltzman M. (1981). Principles of colour technology. 2nd Edition. John Wiley and Sons: New York. 140.

21. Kubelka P. (1948). New contributions to the optics of intensely light scattering materials. Part I. *Journal of the Optical Society of America*, 38(5), 448-457.

22. Standard methods (1962). Standard methods for the determination of colour fastness of Textiles. 3rd edition. *The Society of Dyers and Colourists*.

23. Booth J.E. (1996). Principal of textile testing. 1st Edition. CBS Publishers and Distributors Pvt. Ltd.

24. Saville B.P. (1999). Physical testing of textile. 1st Edition. Elsevier: Woodhead Publishing.

25. Jinlian H. (2008). Fabric testing. 1st Edition. Elsevier: Woodhead Publishing.