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Dyeing Cotton, Wool, and Silk with Allium Cepa

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Abstract - Through the use of a dip-dry-iron-cure procedure, cotton fabric was treated with maleic anhydride, Allium cepa, and Terminalia arjuna all at once, with sodium citrate serving as an catalyst for esterification and free radical polymerization using potassium peroxodisulfate. Dyeing silk and cotton fabric with itaconic acid and maleic anhydride, or both, under the combined Catalysts for esterification and free radical polymerization caused chain polymer cross-linking to a certain extent, according to infrared analysis of the dyed fabrics. The purpose of this thesis is to increase the performance and versatility of dyed substrates by improving the balance of their qualities via the use of natural dyes applied to silk and cotton textiles.

Keywords: Dyeing Cotton, Wool, Silk and Allium Cepa

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INTRODUCTION

This market has shown a marked increase in interest in natural dyes on a global scale. The textile business is no exception to the worldwide movement toward resource and quality of life conservation; after all, satisfying customers has always been associated with offering unique goods and services. Since these chemicals are already biodegradable, have minimal toxicity, aren't allergenic, and are ecologically friendly, using the least hazardous natural dyes to color textiles is a great option. As a natural dye, onions have many uses. Allium cepa is their official scientific name.

The natural dye quercetin, which is found in onion skin, gives natural fibers like wool and silk a range of brown tones. Proteins are the building blocks of both wool and silk, which have the common chemical formula NH2.CHR.COOH. Proteins are able to impart certain polymer characteristics due to their abundance of functional groups. When using acid dyes on wool and silk, COOH and NH2 are the most crucial. Dyeing involves the adsorption and diffusion of solution dyes into the fiber, which brings about physicochemical reactions. Natural dyeing, on the other hand, is still very much an empirical technique. Research into the sorption mechanism and the process itself is severely underrepresented in the literature.

In order to acquire value, accomplish objectives, and meet customer mandates, textile sources are used in the design process. Essentially, this innovative mindset was born out of a need to color textiles using substances other than synthetic and artificial dyes, allowing for a more natural approach. The majority of synthetic pigments are manufactured in factories using petrochemical bases and involve hazardous chemical processes, which pose a threat to our efforts to create an environmentally friendly world. Natural fibers may absorb dyestuff; for example, cotton and linen are cellulosic, so they can take dye. On the other hand, wool and silk are hypoallergenic, flame retardant, hypofiber, and simple to wash. An additional benefit of eco-friendly settings might be the use of natural essential colorants for natural textiles.

The root vegetable, the onion, is the oldest cultivated item in the world. Instead of the fatty bulb, this onion has a protective layer of flavonoids that are absorbed in a multitude of ways via the skin. Because the functions of flavonoids are determined by their structures and arrangements, research have shown that various flavonoids with distinct constructions have varied biological activities. The use of metal salts as mordants in naturally colored fabric goods makes textiles more than merely environmentally beneficial. For both the pre- and post-mordanting processes, the natural colorant was derived from mango bark. We used specialized washing equipment and a little quantity of dyestuff to dye the samples. It was combined with the ultra violet absorption test and the washing fastness test that were conducted using spectroscopy. Comparing the control samples with the mango bark mordant sample—which included both the unmordanted and treated samples with substances like copper sulphate—confirmed a significant improvement over the traditional mordant in terms of the results of the mordanting process.

LITERATURE REVIEW

Agarwal, Jyoti & Sonia (2021) One of the most infamous businesses when it comes to environmental effect is the dyeing industry. Permanent and long-lasting color is added to completed textiles via the dyeing process. Fabrics made from natural fibers may now be dyed using a variety of methods that have been refined over many decades to achieve precise color saturation and durability. Conventional methods of dying natural fibers use a lot of water, a lot of energy, and a lot of chemicals as waste. These chemicals, along with unfixed dyes, are released into water bodies as industrial effluent, which causes a lot of water pollution. As a result, the dyeing sector is the source of several pressing environmental and sustainability problems that need quick attention. Such matters will be clarified and new developments will be covered in this chapter.

Fröse, Anastasia & Schmidtke, Karolina & Sukmann, Tobias & Juhász Junger, Irén & Ehrmann, Andrea. (2018) Dyeing using natural dyes has recently grown in popularity, despite the fact that conventional textile dying procedures generate a substantial quantity of leftovers in the wastewater of textile finishing industries. This manner, we can conserve water and prevent water pollution. Plus, we can achieve a wide range of colors, which gives textile designers more options. Contrarily, natural dyes tend to be less vibrant and more easily bleached by mechanical stress, washing, or ultraviolet sunlight. In this article, we will go over the many natural dye combinations that have been utilized to color various textile fabrics, both with and without pretreatment. The finished textiles may display a wide spectrum of colors, influenced mostly by the fabric type and, in some instances, the pretreatment. Martindale abrasion tests revealed substantial color shifts, in contrast to the little effects of washing and UV treatment.

Ansari et al. (2022) The substrate, cotton cloth, was colored using fresh natural materials. To extract the natural colors, we used fresh flowers of three plants: marigold, hibiscus, and red rose. In this work, three distinct extraction procedures were used to extract the fading pigments found in flowers. The extracted dye on the 100% cotton cloth was set using two distinct mordants: ferrous sulphate ($FeSO_4$) and copper sulphate ($CuSO_4$). Variegated hues of marigold, hibiscus, and red rose blossoms were shown by the findings. These results have the potential to be used to the dyeing of all-natural textiles. The textile industry's use of natural dyes is the focus of this essay.

Gupta, Virendra. (2019) There has been a recent uptick in the use of natural dyes for textile dying, thanks to the stringent environmental regulations in clothing and textiles enacted by environmentally conscious nations. Natural colours are drawing in viewers despite the fact that synthetic colors have harmful side effects, which may cause allergies and toxicity. One sustainable option for colorants is to use natural dyes. Its uses extend beyond textiles to include food colouring, pharmaceuticals, and craft materials. While natural dyes are great for the environment, skin, and eyes, they don't bind well with textile fibres. To fix them, textiles must be mordanted with metallic mordants, which may be harmful to the environment. This means that natural dyes are not completely dominant. This calls for more recent studies into the use of natural dyes on various natural fibres to create textiles that are entirely harmless to the environment. As a result, this review article covers the groundwork of natural dyes chemistry as well as some of the key studies in the field.

Kanchana (2013) The ethnic and local people rely on a wide variety of plant species for their daily needs. Unfortunately, the current generation of ethnic people has lost a lot of the traditional knowledge about natural dye extraction, processing, and use since synthetic dyes are so cheap and simple to get by. To bring back the time-honored practice of dying using natural dyes, the current research was conducted with the aforementioned considerations in mind. This study examined the colour fastness of fabrics dyed with a combination of mordants derived from various plants, including The verbena (Clitoria flowers), the marigold (Targetes erecta Linn), and the pomegranate peel (Punica granatum). The fabrics were dyed under optimal conditions and tested for exposure to light, washing, and rubbing. We also tested the colours for their antibacterial capabilities.

RESEARCH METHODOLOGY

We utilized untreated, commercial-grade maleic anhydride purchased from M/s Macromols India Ltd. Natural dyes derived from Allium cepa and Terminalia arjuna were procured from S/N Eco-N-Viron in Serampore, India (West Bengal). The extracts were water-based and included 50% solid material. We only used laboratory reagent grade chemicals for any other experiments. Before dying or mordanting, the materials that had been scrubbed were immersed in clean water for half an hour. Allium cepa skin scales were used as the dye. Using tannic acid, pretreatment was performed. Iron sulfate, alum, compounds including stannic and stannous chlorides as well as copper sulfate and potassium dichromate were the mordants that were used. Reagents of a laboratory grade were used for all other chemical analyses. Allium cepa's brown scaly leaf (the outer skin) is used to extract color. Using heated 60% ethanol, We removed the scale leaf. The process began with the removal of ethanol using low pressure. After that, the extract was concentrated by shaking it repeatedly with diethylether.

DATA ANALYSIS

DYEING COTTON, WOOL, AND SILK WITH ALLIUM CEPA EXTRACT

The primary goal of conducting the basic allium extract was subjected to spectroscopic examination in order to determine the colorant's chromophores, the extract's absorbance (visible spectrum), and the existence of functional groups (FT-IR spectrum). If we knew how the metal mordant successfully chelates with the dye molecule, we could make better use of this data.

The spectrum of visible light emitted by onion peel

With a maximum at 430 nm (2.720A8) and another at 662 nm (0.399A8) are seen in the methanolic extract of Allium.

Extract FT-IR spectra

The peaks observed in the methanolic extract of Allium are as follows: These infrared wavelengths are: 3412, 2922, 2852, 1721, 1613, 1503, 1446, 1326, 1209, 1093, 1042, 919, 758, and 574 cm^{-1}.

Dyeing

The process of dying was as follows: The process began with a pretreatment of 2% mordant/owf dyeing, and then proceeded to a three-hour dyeing stage using onion scale extract at temperatures ranging from 30 to 408 degrees Celsius. After dipping the colored materials in a saturated brine solution for fifteen minutes, which served as a dye-fix, and after being rinsed with tap water, they were allowed to dry naturally. Pretreatment significantly improved the wash fastness of the dyed fabrics, as measured by the change of shade compared to controlled samples, according to Colorimetric information derived from yarns and textiles colored with tannic acid and metal mordants for cotton and with only metal mordants for silk and wool. In addition to making the colors stronger, it also made the dyeings seem more uniform in tone.

A control group of colored samples was likewise generated for each experiment. Results were excellent when cotton cloth was dyed using the natural dye Allium cepa in conjunction with metal mordant in a step-by-step fashion. Stepwise dyeing resulted in dye absorption rates ranging from 65 to 68% for When exposed to different mordants, cotton, silk, and wool all show increases of 70–74% and 78–82%, respectively. The outcomes of dying cotton, silk, and wool. Lighter hues were achieved by using mordants that had a greater value of L*, which also gives the values of a* and b*. Likewise, a positive a* indicates yellow and a positive b* indicates orange.

Table 1: L*, a *, b *, C, and H values for Allium-dyed cotton fabric

Method	Mordant	L*	a *	b *	C	H	K/S
Pre-mordanting	Control	47.058	3.58	25.20	25.45	81.86	69.10
	Control +tannic acid	46.948	4.11	24.60	24.94	80.46	68.51
	Alum	50.461	4.16	34.10	34.36	83.00	67.20
	Copper sulphate	47.100	2.59	26.60	26.72	84.39	98.66
	Ferrous sulphate	42.234	1.90	14.72	14.84	82.59	124.25
	potassium. dichromate	44.315	5.20	20.25	20.91	75.55	28.78
	Stannous chloride	52.703	7.83	39.84	40.60	78.84	92.08
	Stannic chloride	48.406	6.73	30.52	31.25	77.52	158.97

Table 2: Properties of silk treated with Allium dye, including L*, a*, b*, C, and H

Method	Mordant	L*	a *	b *	C	H	K/S
Pre-mordanting	Control	51.932	10.23	26.37	28.28	68.76	53.18
	Alum	63.247	6.70	53.45	53.87	82.82	130.70
	Copper sulphate	53.826	5.78	33.54	34.03	80.19	83.35
	Copper sulphate	45.333	2.14	13.09	13.26	80.60	227.11
	potassium. dichromate	48.575	5.52	21.61	22.30	75.62	55.13
	Stannous chloride	64.907	11.31	57.05	58.16	78.75	136.11
	Stannic chloride	61.289	10.03	49.31	50.32	78.46	116.16

the fastness characteristics of wool yarn, colored cotton, and silk textiles treated with three distinct metal mordants. Mordants like ferrous sulfate, stannous chloride, stannic chloride, potassium dichromate, and copper sulfate produce a wide range of colors on various materials, as seen in Figure 3.5. The acquired hues were vivid and had exceptional fastness characteristics.

Table 3: Results for L *, a *, b *, C, and H values for Allium colored wool yarn

Method	Mordant	L*	a *	b *	C	H	K/S
Pre-mordanting	Control	45.523	5.18	26.58	27.08	78.93	91.14
	Alum	55.056	21.49	48.98	49.00	91.78	381.20
	Copper sulphate	41.634	3.08	23.04	23.24	82.33	152.03
	Ferrous sulphate	37.916	2.92	14.16	14.46	78.29	539.51
	potassium. dichromate	43.699	3.69	26.79	27.04	82.10	161.85
	Stannous chloride	53.842	13.18	49.57	51.29	75.07	277.85
	Stannic chloride	39.132	3.89	16.67	17.12	76.80	86.77

Table 4: The effects of three metal mordants including Allium on the fastness of wool yarn, silk textiles, and cotton colored under standard circumstances

Dyeing methods	Wash –perspiration – rubbing –light					
	WF	Per acidic	Per basic	Rubery	Rub wet	LF
Cotton (control)	3-4	3	3	3	3	3-4
Cotton(alum)	4	4	3-4	3-4	3-4	4
Cotton (Fe SO4)	4-5	4	4	4	4	4-5
Cotton (Cu SO4)	4	4	4	4	4	4
Wool (control)	3	3	3	3	3	3
Wool(alum)	4	4	4	4	4	4
Wool (Fe SO4)	5	4-5	4-5	4-5	4-5	5
Wool (Cu SO4)	4-5	4	4	4	4	4-5
Silk (control)	3	3	3	3	3	3
Silk(alum)	4	4	4	4	4	4
Silk (Fe SO4)	5	4-5	4-5	4-5	4-5	4-5
Silk (Cu SO4)	4-5	4	4	4	4	4-5

Notes: WF = wash fastness; LF = light fastness

Metal mordant with Allium cepa seems to increase the fastness qualities, especially the light and wash fastnesses, compared to the control samples, as shown by greater dye absorption.

Colour measurements

In Figures 4.8-4.10, you can see the CIElab values and the K/S values for yarn made of cotton, silk, wool. The colorimetric values of Allium-pretreated cotton fabric show a shade change from yellowish brown to brown when dyed with different metal mordants. For cotton textiles, the production of the dye-mordant combination was improved by pretreatment with tanninic acid before mordanting. Considering the potential toxicity of certain mordants, a variety of mordants were used in 2%. The cotton was premordantized on alum, FeSO4, SnCl2, CuSO4, SnCl4, K2Cr2O7, and other chemicals. The skin-extracting water-based allium was used to dye the cotton. The hue color, L* value, and brightness index value were all significantly affected by the different mordants, as shown in Figure 4.8. Stannic chloride had the most favorable results.

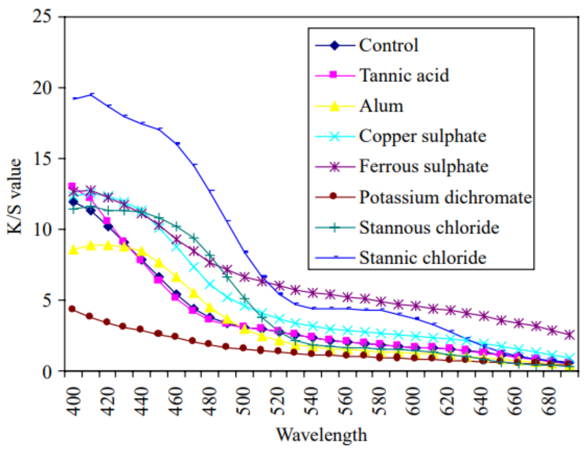

Figure 1 Variation in K/S values for cotton textiles treated with various mordants

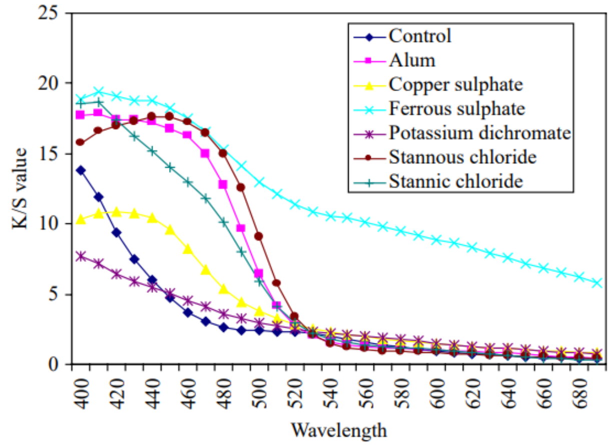

Figure 2 Variation in K/S values for silk textiles treated with various mordants

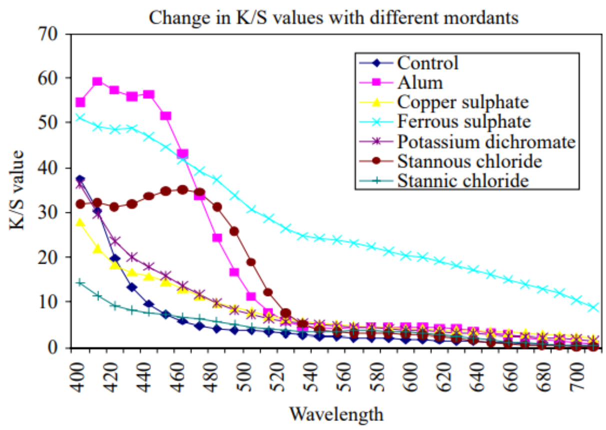

Figure 3 Variation in the K/S ratios of wool fabrics treated with various mordants

In Figures 4.8-4.10, you can see the CIElab values and the K/S values for yarn made of cotton, silk, wool. Silk fabric dyed with Allium after pretreatment shows colorimetric values that range from yellowish brown to pure yellow as a result of dyeings with different metal mordants. Considering the toxicity component of some mordants, a variety of mordants are utilized at a 2% concentration. Figure 4.9 shows that different mordants, such as together with alum, CuSO4, SnCl2, K2Cr2O7, and FeSO4, can produce different hue colors when applied to silk. The different mordants also result in different hue colors, shifts in the brightness index, L*, and K/S ratios. Ferrous sulfate yields the most desirable results.

Dyeings with various metal mordants caused a change in hue from pale brown to dark brown, revealing the colorimetric properties of wool yarn dyed with Allium after pretreatment. As demonstrated in Figure 4.10, different wool yarns can be dyed with different mordants, resulting in different hue colors, Quantities of K/S, L*, and brightness index. Some examples of these mordants include Materials needed include alum, aqueous extract of allium skin. Ferrous sulfate yields the most desirable results. Therefore, iron produced deep tones in all three instances.

Effect of mordanting conditions

Cotton, wool, and silk were found to have excellent fastness qualities after being pre-mordantized using metal mordants. For comparison, we also created control samples without mordant. Consequently, before to the mordanting process, the textiles that had been colored were treated with aluminum hydroxide, potassium dichromate, copper hydroxide, ferrous sulfate, and stannous chloride. The six instances' mordant activities occurred in the following sequences:

- Here is the sequence of K/S values: The use of metal mordants improved the onion's color absorption by cotton fabric, since The chemical reaction in cotton goes as follows: Sn (IV) → Fe → Cu → Sn (II) → Al → Cr.The K/S values are shown here in series.

- Here's how the usage of metal mordants enhanced the silk's color-absorbing capabilities when it came to onions: The following reactions may be followed: Fe → Sn (II) → Al → Sn (IV) → Cu → Cr. Here is the sequence of K/S values.

- Metal mordants were used to enhance the color absorption process. wool yarn for onions, as Fe → Al → Sn (II) → Cr → Cu → Sn (IV).

Fe (II) is the most effective chelator for wool and silk materials, whereas Sn (IV) is the most effective for cotton fibers. Quercetin may form complexes with a wide range of metal ions because to its hydroxy and oxo groups. Because of their higher concentrations of acidic protons, the 3-hydroxy (3-OH) and 4-oxo (Figure 4.11a) groups are the first locations of complexation to occur. Figure 4.11b shows that there is another possible complexation involving 3'- and 4'-OH groups.

Statistical analyses

The analysis of variance was used to measure the K/S values and dye uptake absorbance (in percent) for every dyeing experiment. Three rounds of each therapy were conducted. In each case, the SED (±) was calculated as the standard error of the difference determined.

Fastness testing

As per the Indian standard techniques, the samples that had been colored were analyzed (BIS, 1982). Color washing (IS-687-79), light-fastness (IS-2454-85) using xenotester, rubbing (IS-766-88) using crockmeter, sweating (IS-971-83) by perspirometer, and other specialized tests were conducted. For the stepwise dyeing condition, the results of the metal mordanted samples are presented. the fastness qualities of all three kinds of material have been enhanced by the mordanting process, which includes alum, copper sulfate, and ferrous sulphate. The other three mordants were also subject to similar criticisms. In terms of washing and light fastness, there is a noticeable improvement. As a result, the dye is suitable for industrial applications.

Dye exhaustion

For the purpose of determining the proportion of dye that has been used up (E per cent), the following equation was used:

percent E = [A0 2 Ar/A0] × 100

The absorbance of the dyebath was measured at 430 nm, λmax before and after dyeing, with A0 and Ar representing the variables, respectively. The absorbance was measured at the dye's maximum absorption peak using a Helios UV/Vis spectrophotometer. The method produces excellent, uniform dying results when applied to cotton fabric in stages, beginning with a metal mordant pretreatment and ending with a natural dye made from allium extract. Stepwise dyeing with various mordants results in dye absorption rates ranging between 65 and 68% for cotton, 70 and 74% for silk, and 78 and 82% for wool. Metal mordant-Onion seems to work better at facilitating dye absorption, which in turn leads to greater dye adhesion and, ultimately, higher fastness qualities. Based on what we learned in this research, allium is a great natural dye source for both traditional and future commercial dyeing processes.

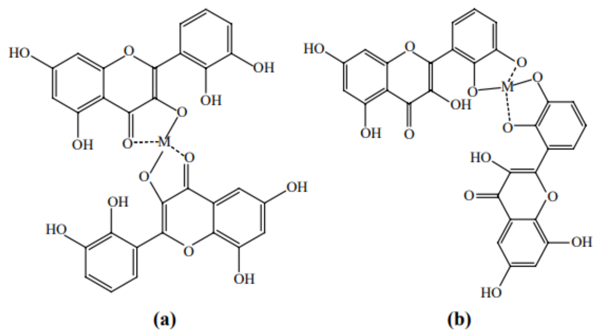

Figure 4 Proposed mordant-dye complex

CONCLUSION

Many studies have shown that the best pH for applying Allium cepa and Terminalia arjuna to silk fibers is "4". Applying Terminalia arjuna and Allium cepa to cotton results in a generally low dye uptake for cotton fiber across the whole pH range studied. The results of this investigation demonstrate that the kitchen waste material known as scale of bulb of Allium cepa has promising dyeing potential. All three kinds of materials had their dyeability and fastness qualities improved when treated with a metal mordant and Allium cepa extract. When compared metal mordanting resulted in a net increase in dye absorption relative to the control samples ranged from 78 to 82% in wool, 70 to 74% in silk, and 65 to 68% in cotton. Onion scales are ideal for natural textiles like silk and wool because to the greater proportion of color strength in these materials.

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