Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(4), 1231-1235 | ISSN:2251-6727

Chitosan : An Eco-Friendly Mordant for Natural Dyes

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(Received: 02 September 2023 Revised: 14 October Accepted: 07 November)

KEYWORDS

Chitosan, Natural dyes, Onosma echinoides and Tagetus erecta

ABSTRACT:

Presently the art of dyeing with natural dyes has gained momentum with the ban imposed on certain synthetic dyes. In search of eco-friendly processes for dyeing with natural dyes research has been focused on identification and standardization of natural dyes. On these lines a study was undertaken to standardize chitosan as a mordant for selected dyes and to assess their colour fastness. Comparison of chitosan mordanted samples was made with that of other two eco-friendly mordanted samples of alum and ferrous sulphate to find the impact of chitosan as a mordant for natural dyes.

1. Introduction

Natural dyes are safe, biodegradable, biocompatible and non-hazardous to human habitat. This has created unstinted demand for the natural dyed products and the faded antiquity is unveiling globally. At present, much concern is manifested in developing the knowledge base for production of fast shades from natural sources on different textiles.

Besides the advantages, the limitations that are responsible for its limited use are their low colour yield, difficulty in standardization, reproducibility of shade, inadequate fastness, time consuming process and fixation (Tamilarasi A and Banuchitra M, 2021). Hence mordants are used to improve the fastness and brilliancy of shades. The most prevalent mordants used in the dyeing industry are alum, stannous chloride, ferrous sulphate and potassium dichromate. But not all mordants are eco-friendly. Stannous chloride and potassium dichromate mordants are found to be hazardous and causing pollution to the environment and hence not utilizing in textile industry (Imani H et al., 2022). Alum and ferrous sulphate are commonly used in the natural dyeing industry as they are considered as eco-friendly (Imani H et al., 2022). Hence, in search of an eco-friendly mordant, chitosan a natural polysaccharide was taken to study its impact as a mordant on natural dyes and was compared with alum and ferrous sulphate.

Chitosan is a naturally occurring polysaccharide which is a deacetylated form of chitin which has varied applications in the area of textiles (Arash et al., 2021). As per the recent literature it was found that chitosan is being used as an auxiliary for dyes which is eco-friendly in nature. It may be considered as cellulose with hydroxyl group in the structure of chitosan (Morin-Crini et al., 2019).

Pretreating the cotton fabric with chitosan modifies the structure of cellulose and makes it cationic. This modification increases the affinity between the dye molecule and cotton fabric (Correia et. al., 2020).

2. Selection of materials:

(a) Dyes: Onosma echinoides and Tagetus erecta

(b) Mordants: Chitosan, alum and ferrous sulphate

(c) Yarn: Mercerised cotton yarn

(d) Chemicals: Laboratory grade chemicals were utilized for dyeing and pretreatment

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3. Methodology:

3.1. Pretreatment of cotton yarn:

The mercerized cotton yarn was boiled in water for 15 to 20 min to improve the rate of dye absorption (Michef R, 1992). Later the yarn was mordanted and dyed with dye sources.

3.2 Dye Extraction parameters:

The extraction and dyeing conditions of the selected dye sources adopted were as follows.

Table: 1 Extraction and dyeing conditions of dye sources

Sources	Medium	Dye material concentration gm/100ml	Alkali gm/100ml	Extraction time (min)	Dyeing time (min)	Wave length (nm)
Tagetus erecta (Flowers)	Aqueous	6	--	60	30	440
Onosma echinoides (Roots)	Aqueous	6	--	60	30	370

3.3 Mordanting procedures:

The pretreated cotton yarn was subjected to all the three methods of mordanting namely premordanting, simultaneous mordanting and post mordanting which was carried out for 30 minutes at 60□C.

3.3.1 Optimization of mordant concentrations:

The amount of mordant for treatment was calculated based on the weight of the yarn that is expressed in terms of percentage. Optimization for chitosan mordant was carried out at 1 to 5% on all dyes. After mordanting these samples were dyed in each source separately. Among the five concentration levels, three percentages were selected for mordanting based on the absorption values and visual appearance.

Table: 2 Optimisation of chitosan mordant concentrations

Dye	Mordant Concentration g/100gm yarn	Percent absorption
Tagetus erecta	1*	13.05
	2*	12.56
	3*	11.69
	4	9.85
	5	8.74
Onosma echinoides	1	18.4
	2	20.7
	3*	12.6
	4*	6.2
	5*	9.8

* Indicates the selected mordant concentrations

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As evident from the table 2, three concentration levels of 1, 2 and 3 percent and 3, 4 and 5 percent were selected for dyeing cotton with Tagetus erecta and Onosma echinoides respectively. In spite of higher absorption values in certain concentration levels, the depth of the shade was poor, hence not selected.

The optimized mordant concentrations that were adopted for alum were 5, 10 and 15 percent and 1, 2 and 3 percent levels for ferrous sulphate.

3.4 Dyeing procedures:

The mordanted samples were dyed in different sources at their particular optimized dyeing and extraction times given in table 1. Chitosan treated cotton yarn dyed with all the dyes has exhibited soft, pastel and lustrous shades. Dark green to dull khaki colours were obtained with Tagetus erecta dye whereas dull green to moderate grey shades were produced with Onosma echinoides dye. The colours obtained with simultaneous mordanting method with chitosan was found to be best for mordanting cotton for both the dyes.

The mordanted concentration levels selected for alum were 5, 10 and 15 percent and 1, 2 and 3 percent for ferrous sulphate. Darker shades were obtained with alum and ferrous sulphate mordants compared to chitosan mordant. Brownish yellow shades were produced using alum mordant and green to grayish brown shades were obtained with ferrous sulphate when dyed in Tagetus erecta. Post mordanting method was found to be best in case of both mordants for dyeing with Tagetus erecta. While, cotton mordanted with alum exhibited grayish blue colour with greenish tinge, ferrous sulphate mordanted samples showed grayish blue to brown. The premordanting method had facilitated deeper shades on mordanted cotton with alum and ferrous sulphate when dyed in Onosma echinoides.

It is evident from the observations made in this study that chitosan mordant facilitated for obtaining very soft, lustrous and pastel shades on cotton. Moreover, chitosan mordant did not facilitate the formation of larks in the dye liquors. Generally lark formation in the dye liquors cause a lot of problem in maintaining the dye process and equipment in the industry. In this respect chitosan might be a good alternative for a dyeing industry in place of alum, which is frequently used as an effective mordant for natural dyes.

3.5 Findings of colourfastness tests on cotton:

Cotton mordanted with chitosan exhibited excellent fastness to sunlight for Tagetus erecta. Very fair fastness was observed in case of Onosma echinoides dye source. The wash fastness was found to be fair to good in all dyed samples mordanted with chitosan. The dyed samples showed excellent fastness to rubbing in all dye sources. The chitosan mordant was found to be sensitive to perspiration in case of Tagetus erecta and good fastness was found for the samples dyed with Onosma echinoides.

Alum and ferrous sulphate mordanted samples from Tagetus erecta exhibited excellent fastness to sunlight. But the samples from Onosma echinoides showed only fair fastness to sunlight. Good fastness to washing and rubbing was observed in the dyed samples of both the dye sources. Perspiration fastness was found to be fair in case of Tagetus erecta whereas for the other it was found to be good. The fastness grades of cotton fabric dyed using Tagetus erecta and Onosma echinoides mordanted with lowest percent of mordants of chitosan, alum and ferrous sulphate are represented in Figure 1 and 2.

As evident from figure 1, chitosan mordanted cotton registered better sunlight fastness when compared to other mordants. It also showed good resistance to colour staining due to alkaline perspiration. Generally, sunlight resistance in natural dyes is not satisfactory. It is interesting to note that Quercetol, the pigment present in Tagetus erecta dye showed excellent fastness when mordanted with chitosan.

The grey shades obtained with Onosma echinoides showed good to excellent fastness properties on cotton mordanted with chitosan, alum and ferrous sulphate. When compared with other mordants, chitosan mordanted samples showed less fastness to sunlight as evident from the figure 2. However, the chitosan mordanted samples exhibited better fastness properties to rubbing both in dry and wet conditions than ferrous sulphate mordanted samples.

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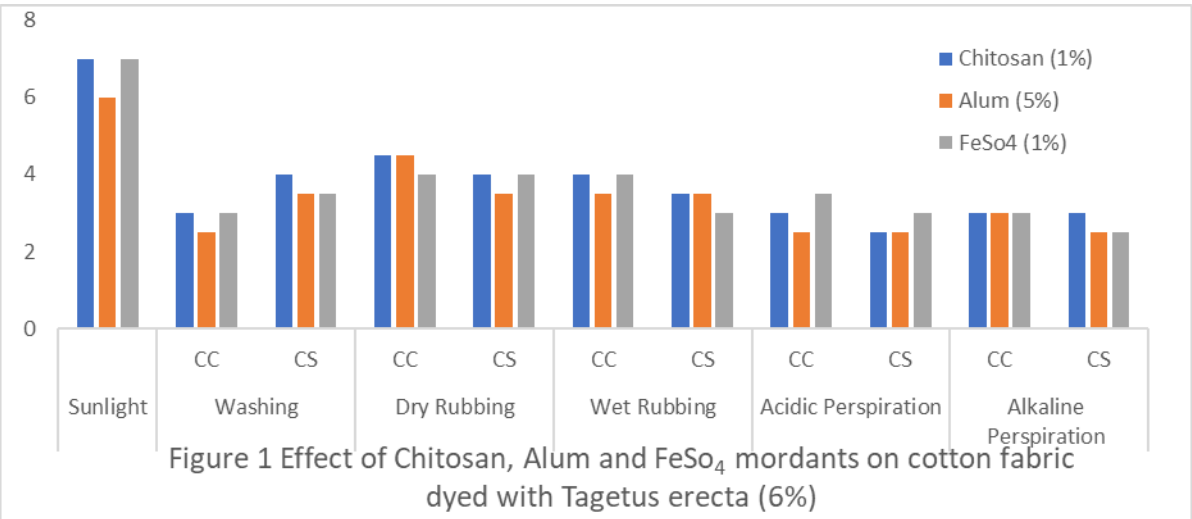

Figure 1 Effect of Chitosan, Alum and $FeSo_4$ mordants on cotton fabric dyed with Tagetus erecta (6%)

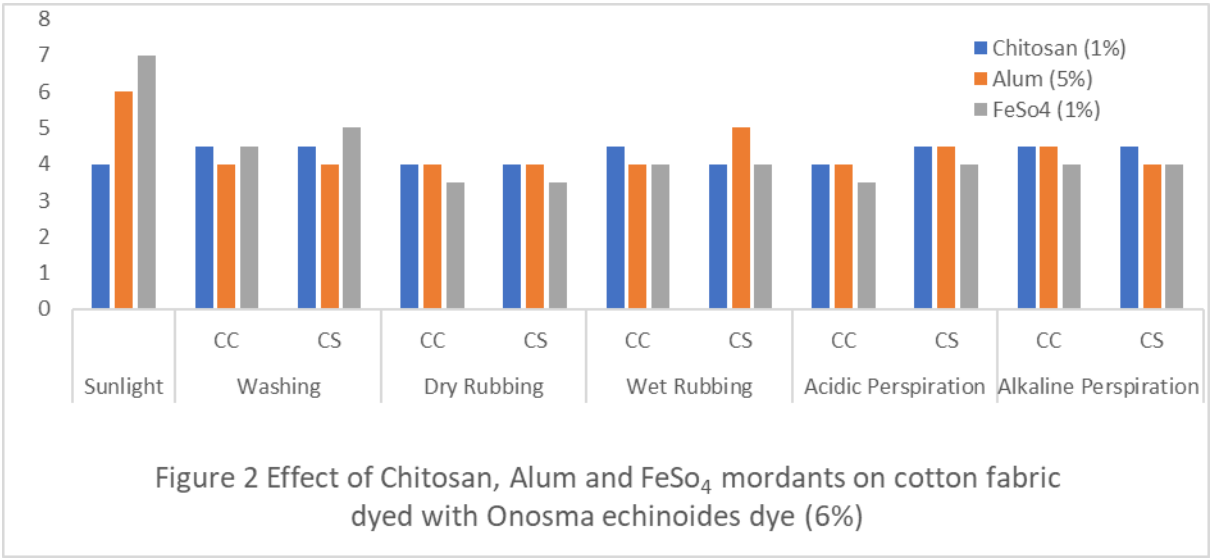

Figure 2 Effect of Chitosan, Alum and $FeSo_4$ mordants on cotton fabric dyed with Onosma echinoides dye (6%)

Conclusion:

Chitosan mordanted concentrations were optimized at 1, 2 and 3 concentration levels for Tagetus erecta, whereas 3, 4 and 5 concentration levels for Onosma echinoides. The optimization was done based on the absorption values and visual appearance. The chitosan mordanted samples dyed in both the dye sources has produced a wide range of soft, lustrous and pastel shades. The dyed samples have exhibited good to excellent fastness to all the general serviceable conditions namely sunlight, washing, crocking and perspiration. It was found that chitosan or alum mordant could be used when bright shades are required on cotton from the selected dyes.

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