Study on the Properties of Natural Fixing Agent ZF and Its Application in the Dyeing with Natural Dyes

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1. INTRODUCTION

In previous years, the application of natural dyes in textile dyeing has been explored all over the world. A great number of natural dyes are faced with the problem of poor color fastness and low dye uptake for their application to the dyeing of cotton [1-5]. In order to improve the color fastness of natural dyes in cotton fabrics, it is urgent to develop the correlative green dyeing and finishing agents.

In this paper, a natural plant fixing agent ZF was prepared and detected. The cotton fabrics pretreated with biological enzyme was dyed with natural dyes and fixed with natural plant fixing agent ZF. The whole dyeing and finishing process was eco-friendly. Moreover, the fixing mechanism was investigated by FTIR and SEM.

2. EXPERIMENTAL

Knitted cotton was provided by Guangdong Yida Co. Ltd., China. Natural dyes were purchased from the Shanxi Shengtang Plant Dyestuff Co. Ltd., China. Natural color-fixing agent ZF was a self-prepared laboratory product.

Preparation of plant color-fixing agent ZF: By comparing the color fixing effects of over 30 kinds of plant juice in cotton fabrics, the best color-fixing agent ZF was selected and the whole preparation was as follows: Plant comminution → compression → filtration of compressed juice → re-mix of multiple plant juice → purification and condensation → finished products.

Dyeing and fixing process: The whole process included dyeing, washing and fixing. Firstly, the cotton fabrics was dyed with 4 %(owf) natural dyes using a liquor ratio of 20:1 at 90-100℃ for 90 minutes. Then the dyed cotton fabrics were washed with 1% natural scouring agent at 90℃ for 30 minutes. Finally, the 4% natural plant fixing agent ZF was used for fixation treatment at 40℃ for 30 minutes.

The dyed fabrics were tested for color fastness to washing according to GB/T 3921.4-1997 and the color fastness to crocking according to GB/T 3920-1997. The Datacolor spectra flash SF600 plus-CT was applied to study the color difference (CMC DE). Formaldehyde content detection was conducted according to GB/T 2912.1-1998 with acetylacetone. Heavy metal ions were detected by X-ray fluorescence spectrometer (ZSX Primus II, Rigaku). Carcinogenic aromatic amines were detected by GC/MS-QP2010 (Shimadzu Co.) and HPLC (Waters 2695, Waters). The FTIR spectra of samples were recorded with a Nicolet AVATAR360 apparatus using KBr pellets with $4cm^{-1}$ resolution. The surface morphological structure of the samples was observed by SEM using a JSM-5610LV SEM (Jeol, Japan) with an acceleration voltage of 20 kV.

3. RESULTS AND DISCUSSION

3.1 Ecological characteristics

The prepared natural plant fixing agent is a light brown liquid with 6.5% solid content. It has good water solubility and the pH value is 4.7-4.8. Acetylacetone method was applied to detect the formaldehyde content and no formaldehyde was found. From the results of the element analysis of the natural plant fixing agent by XRF, there was not any heavy metal ion such as Pb, Co, Cr and Ni and a little K (1.06% in mass), Mg (0.0623% in mass) and Al (0.0152% in mass) were found. Moreover, the results of GC-MS and HPLC showed no carcinogenic aromatic amines include in the fixing agent. The original fluid of the fixing agent has the odor of plant and no peculiar smell was found in cotton products treated with the fixing agent. In general, this natural plant fixing agent was eco-friendly.

3.2 Color fastness and color difference

As shown in Table 1, after the dyed cotton fabrics were fixed with the plant fixing agent ZF, the color fastness to washing and rubbing was improved by 1-2 grades. However, some dyeing samples had certain color shade changes after fixation process. This was attributed to the metal ions such as Mg and Al, which formed the metal coordination bond with the natural dyes and changed the original color.

3.3 FTIR analysis

FT-IR spectrum of the plant fixing agent ZF in the spectral ranges of 4000-400 cm^{-1} is shown in Fig.1. On the basis of the FT-IR analysis, the fixing agent might contain hydroxyl, amine or little carboxyl group, which provided necessary preconditions for the fixing agent to form crosslink film in the surface of the fiber. Besides the self cross-linking, these groups also had the capability to cross-link with dyes and fibers and also the capability to form the hydrogen bond and the intermolecular attraction with dyes and fibers, which improved the color fastness of dyed fabrics.

Table 1 Color fastness and color change of dyed cotton fabrics before and after color fixation process.

Plant dyes	Samples	Washing		Crocking		CMC DE
		F[a]	S[b]	Dry	Wet	
Mercury	Un-fixed	2	2-3	2	1-2	0.24 qualified
	Fixed	3-4	4	3-4	3	
Kavari	Un-fixed	2-3	2-3	2-3	2	0.30 qualified
	Fixed	3-4	4-5	4	2-3	
Himalaya	Un-fixed	2-3	3	3	1-2	0.19 qualified
	Fixed	4-5	4	4	3-4	
Blue	Un-fixed	2-3	2-3	2-3	2-3	0.60 Warning
	Fixed	4-5	3-4	4-5	4	

(a. F, fading; S, staining.)

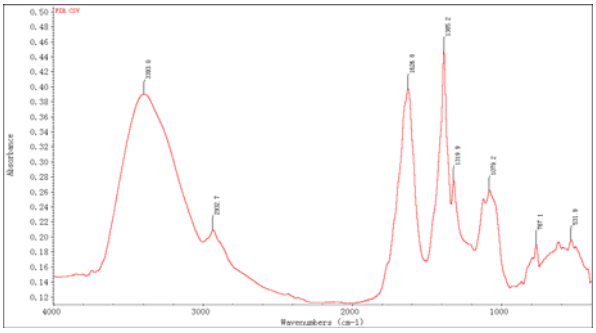
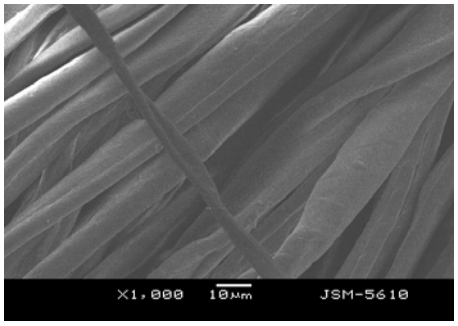


Fig.1. FTIR spectrum of the natural plant fixing agent.

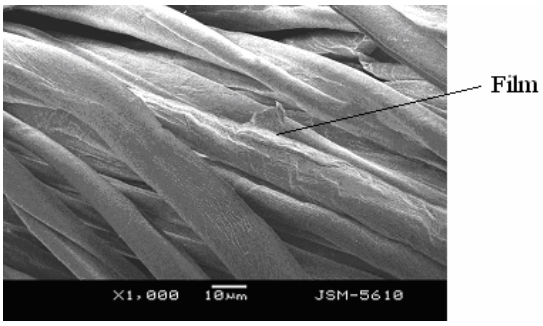
3.4 SEM analysis

SEM images provided information about the morphological structure of the cotton fabrics treated with the natural plant fixing agent. SEM images of cotton fabrics before and after the fixation treatment are shown in Fig.2.

Compared with the cotton fabric untreated with the fixing agent, it is obvious that film structure existed in the surface of the treated fabric. This film sealed off the dyes in fibers, improved the smoothness of fabrics, reduced the friction coefficient, prevented the dilation, dissolution and desquamation of the dyes and enhanced the color fastness to washing and crocking. On the other hand, metal ions such as Mg and Al included the fixing agent were good mordants and could form the coordinate covalent bond with natural dyes and fibers, which helped to increase the combination between the fiber and dyes and improved the color fastness.



a. before the color fixation (×1000)



b. after the color fixation (×1000)

Fig.2. SEM images of cotton fabrics treated the natural fixing agent.

4. CONCLUSION

Natural plant fixing agent ZF is an effective and eco-friendly fixing agent and can improve color fastness 1-2 grades for natural dyes dyeing on cotton fabrics. After the analysis of FTIR, SEM and XRF, ZF mainly depended on cross linking to form film on the surface of fiber. Besides, metal ions complex reaction, cross linking between the fixing agent and dyes and hydrogen bond were necessary to improve the color fastness.

5. REFERENCES

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