MODIFIED BENTONITE WITH DIFFERENT SURFACTANT AND USED AS A MORDANT IN WOOL NATURAL DYEING

Hossein Barani

Department of Carpet, University of Birjand, Birjand, Iran
Corresponding author: barani@birjand.ac.ir

Keywords: Bentonite, Alizarin, Color Strength, Polyethylene glycol, Lecithin.

Extended abstract

Natural colorants are preferred for use compared with synthetic dyes because of their environment-friendly nature, lower toxicity, antibacterial properties, biodegradability, and harmonizing natural shades. Natural colorants are usually obtained from animal (insect) or plant sources such as roots, stems, bark, leaves, berries and flowers without chemical processing [1, 2]. Natural colorants are mainly mordant dyes and usually have weak dye fastness when applied on fabrics. It is common to improve their affinity to substrate or color fastness by applying metal salts as mordants [3]. Bentonite is an absorbent aluminium phyllosilicate that belongs to the class of 2:1 phyllosilicates and has negative charges on its surface. Surface charge of montmorillonite platelets originates from isomorphic substitutions in the crystal lattice and pH-dependent charges of Al–OH (aluminol) and Si–OH (silanol) groups at the broken edges of octahedral and tetrahedral sheets, respectively.

Domestic bentonite is modified before the uses which are dependent of the intended application. These treatment modifications are thermal, mechanical, acidic treatment, inorganic cation exchange, functionalization by organic molecules etc [4]. The possibility of using bentonite instead of metallic mordant in natural dyeing process was assessed [5]. It is stated that the bentonite-pretreated wool samples presented higher dyeing properties compared with untreated wool. In the present paper, wool fabric was pretreated with modified bentonite with a different type of surfactant, followed by dyeing with madder as a natural colorant. The pretreated wool fabric samples were evaluated by scanning electron microscopy (SEM), moisture regain measurement, reflectance spectrophotometry.

The domestic bentonite was modified at 1, 2, and 4 CEC by adjusting the molar quantity of DDAB, PEG400, and lecithin. According to the CEC of the bentonite [6], 1 CEC meant 90 mmol surfactant per 100 g of bentonite. Therefore, appropriated stock bentonite suspension was added drop-wise to an aqueous solution of a prepared surfactant with heating (60 °C) and stirring (approximately 1500 rpm) for at least 60 min. This colloidal solution was used in further pretreatment process of wool fabric. The dyeing process was carried out using the madder solution (100% on weight of fabric sample) and acetic acid for adjusting the pH 5 at L:G of 40:1. The bentonite

pretreated wool fabric sample was introduced to the dyeing bath solution at around 50 °C. The temperature was raised gradually to the boiling point with gradient of 2°C min^{-1}, and followed at this temperature for 1h.

The SEM images indicated that the smooth scales surface is converted to the rough surface due to treating with bentonite platelets (Fig.1). Moreover, The SEM images of treated wool fabric with modified bentonite indicated that the bentonite platelets were partially dispersed and settled on the wool fiber surface. The average size of dispersed bentonite particles was about 0.85 ± 0.41 µm. The elemental analysis of pretreated wool fabric with bentonite indicated this sample included calcium, sodium, silica, and magnesium on the surface.

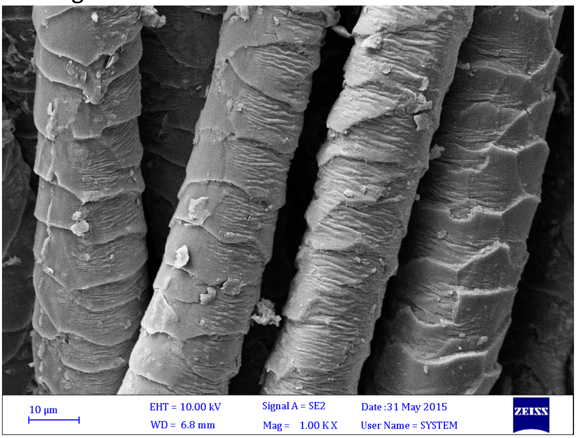

Figure 1. SEM image of wool fiber treated with the surfactant modified bentonite

The average color strength of dyed wool sample pretreated with bentonite was higher than the untreated one and the PEG (CEC= 1) modified bentonite presented the highest color strength (Table 1). It can be concluded that the presence of bentonite enhanced the dye absorption into the wool fiber structure that led to higher color strength. When using bentonite as mordant, the colorant molecules might not be adsorbed on the bentonite surface due to net negative charge on bentonite surface platelets owing to substitutions of trivalent aluminium and magnesium within the lattices [7]. However, these negative charges are balanced by the presence of exchangeable cations (Na^+, Ca^{2+}, etc.) that occupy the interlayer space of bentonite [8]. In addition, the adding of Al^{3+} into the bentonite structure enhanced the dye molecules adsorption as well as color strength of dyed wool fabric.

Table 1. The K/S Value of different wool fabric samples dyed with madder

Sample code	Average Reflectance	Average Color Strength
Untreated	0.19	1.72
Bent	0.18	1.86
Bent-PEG	0.14	2.65
Bent-DDBr	0.16	2.21
Bent-Lec	0.15	2.4

Pretreatment of wool fabric with bentonite or modified bentonite covered the hydrophobic components of wool fiber surface and resulted in hydrophilic surface and in reducing the water drop absorption time. On the other hand, the pretreated wool fabric presented a lower moisture regain compared with untreated wool fabric. Therefore, it can be concluded that the pretreatment with bentonite did not lead to increased absorption of moisture in wool fabric.

References

1. Lichtfouse, E., J. Schwarzbauer, and D. Robert, *Green Materials for Energy, Products and Depollution*. 2013: Springer.
2. Meena, C.R., *Herbal dyes: Growing concept of natural dyes.* Journal of the Textile Association, 2011. **72**(3): p. 193-194.
3. Barani, H., et al., *Optimization of Dyeing Wool Fibers Procedure with Isatis tinctoria by Response Surface Methodology.* Journal of Natural Fibers, 2012. **9**(2): p. 73-86.
4. Djowe, A., et al., *Surface Modification of Smectite Clay Induced by Non-thermal Gliding Arc Plasma at Atmospheric Pressure.* Plasma Chemistry and Plasma Processing, 2013. **33**(4): p. 707-723.
5. Parvinzadeh Gashti, M., et al., *Clay nanoadsorbent as an environmentally friendly substitute for mordants in the natural dyeing of carpet piles.* Coloration Technology, 2013: p. n/a-n/a.
6. Ouellet-Plamondon, C.M., J. Stasiak, and A. Al-Tabbaa, *The effect of cationic, non-ionic and amphiphilic surfactants on the intercalation of bentonite.* Colloids and Surfaces A: Physicochemical and Engineering Aspects, 2014. **444**(0): p. 330-337.
7. Sadeghi, S., A.Z. Moghaddam, and M. Massinaei, *Novel tunable composites based on bentonite and modified tragacanth gum for removal of acid dyes from aqueous solutions.* RSC Advances, 2015. **5**(69): p. 55731-55745.
8. Epstein, M. and S. Yariv, Visible-spectroscopy study of the adsorption of alizarinate by Al-montmorillonite in aqueous suspensions and in solid state. Journal of Colloid and Interface Science, 2003. **263**(2): p. 377-385.