Case Report

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Merino Staining Process Utilizing Aqueous Nitrate at Fairly Low Temperatures

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Abstract

Because they are a non-fluid medium, fluid smelling salts give water a number of real qualities, like a low subatomic weight and a high porousness.Through ecological processing, it has been widely used to improve the luster, softness, and dyeing properties of cellulosic fibers.However, not many people have reported using liquid ammonia to dye treated wool, particularly at lower temperatures.Before dyeing the wool using a standard wool dyeing machine, in this instance, a continuous liquid ammonia finishing machine was used to batch process the wool.By dissolving the disulfide bonds between cystines, the treatment with liquid ammonia made it simpler for dyestuff to enter the fiber. As a result, scale flakes and cuticle cracks developed on the fiber surface.In addition, the dyeing temperature could be reduced to 85 °C with only a 3–5% decrease in fiber strength, and wool dyed with Lanaset and Lanasol CE dyes had higher uptakes and K/S values than untreated wool.Chemical auxiliaries from Miralan LTD, on the other hand, can lower the dyeing temperature for reactive dyes to 70 °C and reduce fiber strength by 8 to 10%. Dyeing wool with liquid ammonia can be done at a temperature lower than boiling (100 °C), with less energy required, and with less loss of wool fiber strength.Because it makes it possible to use low-temperature dyeing technology in the industrial sector, the method is important and has a lot of value.

Keywords: Liquid ammonia • Wool • Low-temperature dyeing • Metal complex • Reactive dyes

Introduction

The cuticle, cortex, medulla, and cell membrane complex make up wool, a complex protein compound.A hydrophobic layer of eicosanoic acid and 18-methyleicosanoic acid that can bind to proteins in ester and thioesters covers the cuticle in a neat pattern.As a result of the cross-linking, the surface of the wool may become denser, preventing the diffusion of chemicals and dyes.Wool fiber dyeing typically takes place at a boiling temperature for an extended period of time in order to encourage dyes to diffuse through the cuticles and along the membrane complex into the fiber's interior and then into the cortex during high-temperature swelling [1]. However, prolonged boiling results in a significant loss of fiber strength, lowering the luster and brightness of wool fiber and driving up energy costs.As a result, methods for dyeing wool at low temperatures have been studied for a long time.In order to achieve low-temperature dyeing, these intended methods can alter the wool's cuticle or complex cell membrane structure to either increase the dye's adsorption and diffusion capacity or decrease the dye's activation energy for diffusion.Dyeing wool at low temperatures is crucial for making spinning and weaving easier and reducing wool fiber strength loss [2].

In recent years, the study of ultrasonic waves, plasma, enzymes, and chemical additives has been the primary focus of low-temperature dyeing of wool fiber.In wool fiber dyeing, it has been demonstrated that ultrasonic waves can break the cuticle, increase dye uptake, and lower the dyeing temperature to 70–80 °C. Surface etching and hydrophilic groups increased while simultaneously improving the fiber's dyeing and anti-felting properties when it was treated with an inert gas plasma [3]. Plasma-treated wool fibers can typically be dyed at 60–70 °C. At low temperatures, wool has also been dyed with enzymes and chemical aids [4]. Enzymes primarily increase the rate at which dye molecules diffuse between cells on wool by hydrolyzing the CMC layer.Enzymes and other physical or chemical pretreatments are said to work together, as well.It also hydrolyzes the membrane complex and breaks some disulfide bonds [5]. The dyeing temperature drops as the adsorption and diffusion rates of the dyestuffs increase.Chemical additives increase dyestuff adsorption and dissolution by breaking the cuticle, dissolving disulfide bonds, or increasing salt and hydrogen bonds. Enzymes, on the other hand, are extremely temperature- and pH-sensitive, making their storage and quality control challenging. However, a lack of equipment makes industrializing plasma and ultrasonic waves difficult. Chemical additive approaches to low-temperature dyeing have the advantages of being simple to use, easy to store, and have a significant impact. On the other hand, the chemical easily destroys the wool's distinctive pattern.Therefore, developing a low-temperature dyeing method for wool that is both gentle and commercially viable is of great practical significance and value [6].

The modern international integration of mechanical, chemical, automation, and various other high-tech integrated green environmental protection technologies is known as liquid ammonia finishing. Wool can be treated with liquid ammonia because cotton textiles are frequently processed with the liquid ammonia finishing machine. In light of the fact that the application of liquid ammonia to the wool did not alter its chemical or physical structure, researchers in a variety of laboratories have investigated the dyeing properties, surface characteristics, and thermodynamic properties of wool. Consequently, it appears likely that the treatment improved dyeing properties by causing a slight relaxation of the endocuticle or cell membrane complex surface [7].

In contrast to previous studies, this one focuses on the effects of pretreatment with an industrial continuous liquid ammonia finishing machine on wool surface properties and low-temperature dyeing properties.The Raman spectrum, x-ray photoelectron spectroscopy (XPS), and scanning electron microscopy (SEM) were used to examine wool's chemical structure and surface characteristics [8]. The metal-complex dye Lanaset and the reactive dye Lanasol CE were then used to dye the wool. Before and after the treatment with liquid ammonia, the dyeing temperature, dyeing rate, K/S values, and fiber strength were compared [9].

Materials and Method

Ammonia Treatment with Liquid

The finished wool was impregnated for one minute at 33.4 °C in a continuous liquid ammonia finishing machine made by Kyoto Machinery, Kyoto, Japan.The treated wool was then dried at 110 °C and washed at 50–70 °C to remove the excess ammonia [10].

Dyeing that reacts

Lanasol Red CE and Blue CE were utilized for the reactive dyeing of treated wool (LAT) and untreated wool (W).The liquor-to-water ratio was 1:10, and an acetic acid-sodium acetate buffer solution was used to bring the pH level up to 5.0. The dyeing time ranged from 0 to 120 minutes, and the temperature was raised from 40 °C to 70 °C at a rate of 1 °C/min. The leveling agent Miralan LTD and the dyestuffs had respective concentrations of 3% (o.w.f) and 1% (o.Following the dyeing process, the solid-color processing of reactive dyes took 20 minutes at 65 °C.After bringing the pH level up to 9, sodium carbonate was used to wash the dyed wool for five minutes before acetic acid neutralized it for ten minutes.The dyeing curves of reactive dyestuff at various temperatures [11].

Results and Discussion

Analyses of Chemical Structure

The exocuticle, or cuticle region, contains cystine in the form of numerous disulfide bonds and has the highest sulfur content. In wool's Raman spectra, S-Sbonds, amide bands, aromatic amino acids, and cysteine S-O, S-H bands are said to be the more obvious ones [12].

The S-S stretching vibration band has three distinct conformational states: 505 cm^{-1} (gauche to gauche), 515 cm^{-1} (gauche to trans), and 536 cm^{-1} (trans to trans). The intensity of the characteristic vibration bands decreased following treatment with liquid ammonia, and there were two new peaks at 2420 cm^{-1} and 572 cm^{-1}, respectively. The characteristic vibration band of wool is an S-S stretching vibration band between 500 and 700 cm^{-1}, whereas the S-H stretching vibration of cystine is 2565 cm^{-1}.The stretching vibration of the S-H band caused by liquid ammonia may account for the peak at 2420 cm^{-1}. On the other hand, the peak at 572 cm^{-1} suggested that a change in the S-S bond conformation led to the formation of a new conformation [13].

The Langmuir adsorption isotherm curve was in line with the dyeing rate of LAT. The dyeing rate initially increased rapidly before increasing gradually until dyeing equilibrium was reached. LAT had a significantly higher dyeing rate than W, particularly during the initial dyeing stage. This may be in part due to the following factors:b) Liquid ammonia broke through the lipid layer to expose more hydrophilic groups, increasing the dye's affinity for wool fiber. a) A treatment with liquid ammonia can dissolve surface scales, lowering the barrier that prevents wool dyeing and allowing more dye molecules to enter the fiber.c). The dyeing site was increased because wool has a disulfide bond that can be broken down by liquid ammonia into a sulfoalanine.

When wool was dyed at 100 °C, liquid ammonia had less of an effect on the dying process as the temperature rose. In hot and humid conditions, the surface scales completely open, dye molecules can quickly penetrate fiber, and dyeing exhaustion reaches its peak. Hot and humid weather is the leading cause of exhaustion during high-temperature dyeing [14].

At 100 °C, LAT can be dyed for 30 minutes, whereas W can be dyed for 40 minutes. When LAT was dyed at 85 °C, the equilibrium dyeing rate reached 99 percent, which has a significant dyeing effect.However, when wool was dyed at 85 °C, the dyeing equilibrium times of W and LAT were 80 and 60 minutes, respectively. The dyeing rate of Blue 2R was slightly higher than that of Red G, but only slightly so. When heated to 85 °C for 60 minutes, the dyeing properties of W and LAT enable Miralan LTD to promote the dissolution and dispersion of dyes and reduce aggregation.Blue 2R, Red G, and Grey G are the three primary colors of the Lanaset series of dyes. The dyeing rate is higher than that of W under the same conditions because of the interaction between Miralan LTD and liquid ammonia. As a result, dye molecules can more easily and uniformly attach to fiber. When Lanasol Red CE was used to dye wool, the dyeing rate of LAT was 88.8%, which was 26.7% higher than that of W when the temperature was raised to 70 °C. Additionally, it can reach over 95% after being held at 70 °C for 30 minutes [15].

In contrast to LAT, liquid ammonia can bring dyeing equilibrium to 100 °C in 20 minutes. When compared to Lanasol Red CE and Blue CE, the dyeing rate of Blue CE was found to be higher than that of Red CE. Dyeing equilibrium times for W and LAT were 70 and 50 minutes, respectively, at 85 °C; Dyeing equilibrium times for W and LAT were 80 and 120 minutes, respectively, at 70 °C.

Conclusion

This work provided a low-carbon, eco-friendly, and wool dyeing-friendly method that can lessen the need for chemical additives and wastewater treatment, conserve energy, and cut emissions at the same time. The treatment with liquid ammonia partially broke the wool's disulfide bond and surface scale, making it easier for the dye molecules to adsorb and diffuse into the wool. takes longer to dye than LAT, particularly at low temperatures. In addition, LAT dyed with Lanasol CE can be brought down to 70 °C by adding Miralan LTD. LAT fiber dyed at 85 °C or 70 °C had the same color difference, fastness, and K/S value as W dyed at 100 °C. On the other hand, wool's single fiber breaking strength was significantly affected by temperature. The single fiber strength of wool dyed at 100 °C experienced the greatest decrease, while that of wool dyed at 70 °C decreased by only 5%.

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