Technology of Bleaching of Wool with Application of Electrical Discharge Non-linear Bulk Cavitation

Tatyana Asauliuk[1], Julia Saribekova[2], Olga Semeshko[2]

1. Chemical Technologies and Biochemical Synthesis Department, Kherson National Technical University, UKRAINE, Kherson, Berislavske highway 24, E-mail: asauliuk@mail.ru

2. Recearch Sector, Kherson National Technical University, UKRAINE, Kherson, Berislavske highway 24, E-mail: solgaya@gmail.com

Abstract *– Effect of preliminary short-term electrical discharge treatment of wool on quality of bleached fiber has been investigated. It has been established that the modification of wool fiber through effect of electrical-discharge nonlinear bulk cavitation contributes to lesser damage of fiber during the peroxide bleaching.*

Key words –bleaching of wool, fiber modification, electrical discharge treatment, cavitation, whiteness, wool fiber damage.

I. Introduction

Wool is a valuable nature raw fiber for textile materials production. Domestic manufacturers utilize peroxide bleaching of wool. The advantage of this method lies in its low cost, simplicity and environmental safety.

But current methods of wool textiles bleaching are characterized by high energy consumption and often result in undesirable damage of fibers during treatment. Besides, fibers damaged by bleaching become more prone to hydrolysis caused by the dye bath acid which has negative effect on the subsequent operation of dyeing with acid dyestuffs.

In this connection, the improvement of wool bleaching process is of particular interest, as it will allow minimizing the fiber damage while achieving higher whiteness.

Analysis of the scientific-technical information [1-2] shows that one of the most effective ways for solving the problems of increasing the process rate and enhancing the equipment performance, while reducing its energy and materials consumption and improving product quality, is through physical and physical-and-chemical methods of fibers surface modification.

These methods include applying the phenomenon of electrical discharge non-linear bulk cavitation (EDNBC). The research shows that effect of the acting properties of electrical discharge treatment (EDT) on wool results in change of its physical and mechanical, processing, sorption and chemical properties [3]. During the process, the modification occurs without essential destruction of the wool keratin, as opposed to chemical treatment methods.

Fiber treated this way is characterized by the reduced felting ability due to compaction of its inner structure and surface smoothing, and by increase of the sorption sensitivity to process solutions caused by increase of the macro- and micropores quantity.

The objective of this work was to determine possibility of bleaching wool fibers that had been modified by applying electrical discharge non-linear bulk cavitation.

II. Materials and methods

In the research, semifine-wool tops of homogeneous structure were used. The electrical discharge treatment was performed on laboratory setup Vega-6 (Fig. 1) designed by scientists of the Institute of Pulse Processes and Technologies of The National Academy of Science of Ukraine (Nikolayev city) jointly with scientists of Kherson National Technical University.

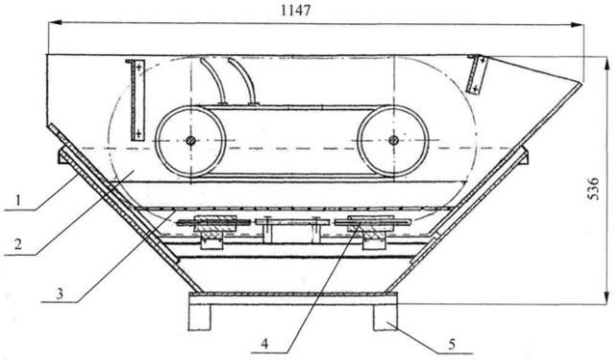

Fig. 1. Schematic illustration of production block of the laboratory setup Vega-6: 1 – vat; 2 – conveyor; 3 – protective grid; 4 – electrodes; 5- shock-absorber

Equipment performances are presented in Table 1.

TABLE 1

EQUIPMENT FEATURES

Name of the parameter	Value
Mains current	AC, single phase
Frequency, Hz	50±0,1
Supply voltage, V	220±22
Efficiency, at least	0,7
Operating voltage, kV	15
Pulse repetition frequency, Hz	1,5
Capacity of the capacitor bank, uF	0,5
Power consumption, W	400

The treatment was conducted in plain water at liquor ratio M=200 and temperature of 25°C. The duration of treatment applied was 180 seconds.

Wool fabric was bleached according to the traditional method at temperature 45°C in bath of the following composition: superoxol – 30 g/l, sodium silicate – 3 g/l, SAS – 1 g/l.

The quality of the bleached modified wool fibers was assessed by the whiteness index and by the rate of wool keratin damage during bleaching. The experimental data obtained were compared with similar parameters of bleached untreated wool.

III. Results and discussion

The experimental research shows that preliminary electrical discharge treatment contributes towards the

increase of whiteness of unbleached tops by 4-5%; this is caused by removal of adipoceratous substances remnants, natural pigments, lipids and cinereous substances included in the structure of the cuticular cell membrane from the fiber surface, as well as by wool fiber surface smoothing under the electro-hydraulic effect.

Analysis of the research results shows that the whiteness indexes for untreated and modified wool differ only insignificantly (48.9% and 48.3% accordingly).

As wool fiber integrity is an important property of bleached wool, the next phase of the research studied the effect of electrical discharge pre-treatment on the rate of fiber damage during bleaching.

To determine the level of wool fiber damage during bleaching, methods based on wool solubility chemical reagent solutions and methods utilizing specific dyes were applied.

The data characterizing effect of electrical discharge pretreatment on the level of bleached wool fibers damage are presented in Table 2.

TABLE 2

EFFECT OF ELECTRICAL DISCHARGE TREATMENT ON LEVEL OF WOOL FIBER DAMAGE

Fiber	Solubility in solution, %		Color yield, K/S	
	0.1 H NaOH	UHR	Diazol Scarlet R	Methylene Blue
Unbleached				
Untreated	7.5	4.9	5.29	24.01
Modified	5.5	3.1	2.205	6.609
Bleached at 45°C				
Untreated	10.2	8	6.609	26.79
Modified	9.4	4.9	6.078	14.17

The solubility of wool in alkali characterizes the hydrolysis degree of the main polypeptide chains of keratin. Electrical discharge treatment slightly reduces solubility of unbleached wool fiber which is indicative of higher integrity of wool. This relationship holds true for wool samples bleached at 45°C.

The degree of wool solubility in urea-hydrosulphite reagent (UHR) characterizes presence of disulfide bonds in keratin. Solubility of both unbleached and bleached modified fiber in urea-hydrosulfite reagent is lower than solubility of untreated fiber. This can be explained by formation in modified wool of stronger lanthionic bonds that are more resistant to action of urea-hydrosulfite reagent.

Coloristic methods for assessment of wool fiber damage level are based on determining the wool receptivity to specific dyestuffs. The dye-receptivity to Diazol Scarlet R (Pauli's diazo reaction) is an indirect evaluation of level of damage to the scale layer of wool fiber, and receptivity to the Methylene Blue is a characteristic of level of damage caused to cortex. The intensity of dyeing with specific dyes is expressed in terms of Gurevich-Kubelka-Munk function (K/S).

The results of dyeing with Diazol Scarlet R and Methylene Blue show that after pretreatment of wool with electrical discharge, the fiber coloring intensity reduces significantly, which is indicative of scale layer compaction and preservation of cortex under influence of EDNBC active properties.

It is noteworthy that electrical discharge treatment contributes to lesser damage of cuticule and cortex during bleaching. Thus, coloring intensity of EDNBC-pretreated wool fiber dyed with Diazol Scarlet R and bleached at 45°C is lower than that of untreated wool. The color intensity of modified wool bleached at 45°C and dyed with Methylene Blue is twice lower than of untreated wool bleached at the same temperature.

Conclusion

Based on comprehensive analysis of bleached wool fibers principal quality parameters study (whiteness, degradation), it has been established that electrical discharge pre-treatment of wool contributes to its higher integrity in course of peroxide bleaching.

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