Recent Aspects of Eco-friendly Textile Processing

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Abstract

The recent aspects of eco-friendly textile processing, in particular bio-scouring of cotton and shrinkproofing of wool are described.

Introduction

Recently environmental problems become more and more critical in every field. In the textile industry eco-friendly textile processing is strongly requested. There are many approaches for the processing. The processes to reduce or replace, recycle, and reuse, that is 3R, are suggested. The reduction or replacement of chemicals, in particular chlorinated compounds, by naturally-occurring materials is one of the most important processes. In particular reduction of absorbable organic halogens, AOX is a very extensive subject matter in the textile processing. The use of enzymes as naturally-occurring materials has been tried strongly. The many kinds of enzymes are employed or have possibilities to apply to the processing as follows: 1) desizing of starch paste (α-amylase), 2) scouring of silk (protease), 3) retting of flax (pectinase), 4) modification of cotton, flax or rayon (cellulase), 5) modification of wool or silk (protease), 6) degradation of residual hydrogen peroxide (catalase), 7) soaping of unfixed reactive dyes (peroxidase), 8) bleaching of denim (laccase), 9) bio-washing of denim (cellulase), 10) bio-polishing of Tencel (cellulase), 11) scouring of cotton (pectinase), 12) bleaching of cotton (peroxidase or laccase), 13) shrinkproofing of wool (protease or keratinase), 14) degradation of dyestuffs (peroxidase or laccase), 15) desizing of polyvinylalcohol paste, and 16) weight reduction of PET. The terms from 1) to 11) are currently available in the textile industry. However the terms from 12) to 16) are not yet and required strongly and quickly to be achieved.

Experimental

With the enzyme scouring a prototype machine for continuous operation was designed and constructed. The machine consists of six components: pricker, enzyme bath, timing scray (for enzyme application), wet fractioning, washing, and folding. The volumes are 4 t for the enzyme bath, 2 t for the timing scray, and 5 t for the washer. The total length, width, and height of the machine are 15.7 m, 3.7 m, and 3.8 m, respectively. The roller width is 1.8 m. The optimum conditions for the operation were checked using this machine [1].

With the shrinkproofing of wool the detailed experimental conditions are shown in the poster presentation of this symposium (Sung Mi Cho, Toru Takagishi, and Mitsuru Takagishi, "Shrink-proofing of Wool Fabrics by Pulse Corona Discharge and Enzymes").

Results

As one example, bio-scouring of cotton fibers using pectinase has been done [1]. Bio-preparation of cotton fibers using enzymes is noted from the standpoint of ecology, safety, and quality. Bio-scouring has many advantages compared to the conventional alkali scouring. At present bio-scouring, that is enzyme scouring, is usually carried out using a liquor flow dyeing machine. A continuous bio-scouring machine is strongly requested in the industry of textile finishing. The Cotton Eco-friendly Society which we have established eight years ago designed and made a new type of continuous bio-scouring machine. A prototype machine was set up in Tokushima Factory, Kurabo Co. The results from continuous bio-scouring using pectinase were compared to those of the conventional alkali treatment system. The removal of pectin using the enzyme was not as great as that with alkali. Also, the water absorbency for the fabric treated with the enzyme system is slightly less than that for the alkali system. However, it is likely that the continuous bio-scouring values are acceptable enough for subsequent bleaching and dyeing. With the bio-scouring system, the mote on row cotton fabrics was not thoroughly removed; however, the residual mote had disappeared by the subsequent cold-pad-batch bleaching with hydrogen peroxide. No dyeability problems arose after the enzyme scouring and bleaching. The

consumption amounts of steam, electric power, and water were estimated. The continuous bio-scouring system has many advantages compared to the alkali system. With enzymes, the steam required was one-third and water required was about one-tenth as compared to NaOH, although electric power was the same. The continuous scouring machine used for this experiment was only a prototype. Many aspects, in particular the scouring treatment speed, must be improved. The final goal is to create an optimal continuous system for desizing, scouring, and bleaching of cotton fabrics using enzymes.

Many approaches are proposed to prepare washable wool. The most popular and present methods are the chemical treatments with chlorinated compounds and polyurethane resin. Monopersulfate, hydrogen peroxide, potassium permanganate, and ozone are also effective. However, these compounds such as the chlorinated compounds and potassium permanganate will be prohibited in near feature by the ecological reasons. Also the resin treatments are no good for the handling of the treated fabrics. The other approaches such as the treatments by enzymes, low temperature plasma, atmospheric pressure plasma, and pulse corona discharge are proposed.

The use of enzymes as the naturally-occurring materials has been tried in the place of chemicals for shrinkproofing of wool from the viewpoint of ecology. However it was found that shrinkproofing of wool fabrics is difficult to be achieved by enzyme treatment alone. We already showed that shrinkproofing is obtained considerably by combined low temperature plasma/enzyme treatment [2]. Moreover we developed to use pulse corona discharge instead of low temperature plasma before enzyme treatment. Both the low temperature plasma and pulse corona discharge are ecological due to the dry process.

In this article treatment of wool fibers and fabrics by the pulse corona discharge and various kinds of enzymes, in particular a purified keratinase with a single component has been carried out to improve their shrinkage. Tensile strength, weight loss, and hand values of primary hand expressions after the dual treatment of pulse corona discharge and enzymes were examined. Furthermore the morphology of scales of the treated fibers was observed under the dry and wet conditions using an environmental SEM, ESEM.

The pulse corona discharge alone did not show the shrinkproofing. Thus the pulse corona discharge/enzyme treatment was done. The relation between area shrinkage and treatment time or concentration of crude or purified keratinase was investigated. To clarify the relation between area shrinkage and yarn tensile strength, these two parameters were plotted. The strength decreased with decreasing the area shrinkage. The pulse corona pretreatment suppressed the decrease of strength significantly also. When the two kinds of enzymes, crude and purified keratinases were compared, the decrease of tensile strength was very severe for the crude keratinase. In this experiment the most satisfactory enzyme for shrinkproofing was the pure keratinase. In this case the decrease of strength was less than 10% relative to the original fabrics when the 5% of area shrinkage was attained.

Koshi (stiffness), Shari (crispness), Fukurami (fullness and softness), and Hari (spread, anti-drape) of the wool fabrics investigated by KES method were not changed after the dual treatment compared with those of the untreated fabrics.

The SEM pictures of wool treated with the enzymes alone indicated that the scales on the surface undergo severe damage after the enzyme treatment. This might result in the decrease of yarn tensile strength. However the damage disappeared thoroughly after the dual treatment. In addition the scales were disappeared smoothly or closed even if the pictures were taken under the wet condition using an environmental SEM, ESEM. It is likely that this situation induces the shrink resistance with little change of strength.

Conclusions

It was found that the prototype machine for continuous bio-scouring which we established is very effective. However it is necessary to improve the scouring treatment speed.

With the shrinkproofing of wool the purified keratinase was proved to be useful and practical after the pulse corona discharge.

References

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