Shrink Proofing of Wool Fabrics by Titanium Oxide Photocatalytic Reaction

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Abstract

Shrink-proofing processing of wool fabrics is practically carried out by means of oxidation of wool with choline and/or covering of wool surface with resins. But, these are not necessarily environmentally friendly process causing a waste fluid containing organic chlorine compounds. Development of alternative method using more environmentally friendly process is desired. In this study, utilization of titanium oxide, TiO_2, photocatalytic reaction for the shrink-proofing of wool has been examined. It was found that the treatment of wool by TiO_2 photocatalytic reaction gave good shrink-proofing characteristics to wool fabrics.

Introduction

Wool is highly specific and consists of hydrophilic protein fiber bundle and the bundle is covered with distinctive hydrophobic cuticles. From this constitution wool has many specific functions such as moisture retentive, water-repellent, breathable, flame resistant, drapeability. However, the largest disadvantage of wool is shrinking nature in the aqueous machine washing process. A dry-cleaning is, therefore, indispensable for wool fabrics to prevent the shrinkage. On the other hand, pressures for the utilization of organic solvent for dry-cleaning has been remarkably increased from the environmental point of view. Consequently, machine washable shrink-proofing wool is strongly requested at present.

In this study, we have considered several methods for the shrink-proofing processing of wool fabric by means of ozone oxidation, oxidation by titanium oxide photocatalytic reaction, plasma treatment, corona discharge, and enzyme treatment.

Experimental

Wool fabrics used in this study was worsted fabric obtained from Gurots Becceltic Japan. The wool fabrics were scoured with boiling water for 30 minutes before the experiments. Anatase-type titanium dioxide powder was dispersed in water (0.4g/ l). Wool fabrics were soaked in the titanium oxide solution. Therewith black-light fluorescent lamp (Toshiba FL20S.BLB-A) that radiates mainly 352 nm of UV light was employed at 50mm distance from the fabric substrate. This irradiation experiments were carried out at 25°C for each 1 hour on two sides of the fabric. After drying, the fabric sample are machine–washed (Toshiba VH-M22.HS) (bath ratio of 30:1, 25°C, 60minutes) in order to evaluate the area shrinkage. In order to examine the effect of the combination with other treatment for the shrink-proofing of wool, enzyme treatment has been carried out after the titanium oxide photocatalytic reaction. Enzyme used here is a protease, 'Bioprase APL-30', obtained from Nagase Biochemical Co., Ltd. The enzyme concentration was 4g/l, with buffer (0.1M-KH_2PO_4/NaOH, pH8) at 50°C for 3hours in the bath ratio of 150:1. After the enzyme treatment, these wool fabrics were boiled for 10minutes to denaturalize the enzyme and washed out with water. The shrinkages of the TiO_2 and enzyme treated wool fabrics were also evaluated by the machine washing. Tensile strengths and tear strengths of the treated wool fabrics were also examined using a tensile strength tester (Shimadzu Autograph) and a Elmendorf tear-strength tester (Yasuda Seiki Seisakusho Ltd.).

Results and Conclusions

Fig.1 shows the area shrinkage of wool fabrics after machine washing. The srinkage of TiO_2 treated wool fabrics has been compared with that of untreated wool fabric, as well as with plasma and enzyme treated ones. TiO_2 treated wool fabric shows less shrinkage than untreated fabric. Hydroxyl radical formed by the TiO_2 photocatalytic reaction seems to act a role to modify the wool fabric surface to be more hydrophilic similar to that by the choline treatment. The shrink-proofing effect of the combination of the TiO_2 treatment and the enzyme treatment is as effective as that of the plasma treatment.

Fig.2 shows the tensile strength of the treated fabrics. Plasma treatment brings about remarkable increase of tensile strength, whereas it causes remarkable decrease of tear strength as shown in Fig.3.

It can be seen that the combination of TiO_2 treatment and successive enzyme treatment of wool fabrics gives good shrink-proofing characteristics with less changing of the strengths of the fabrics.

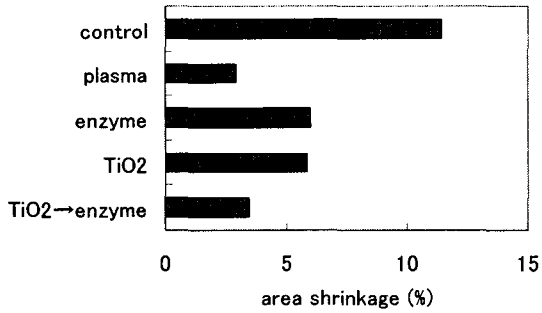

Fig.1 Relation between area shrinkage and treatments

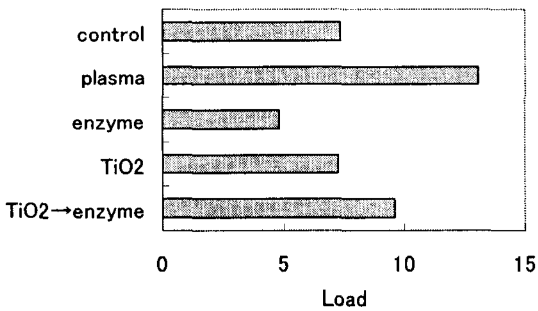

Fig.2 Relation between tensile strength and treatments

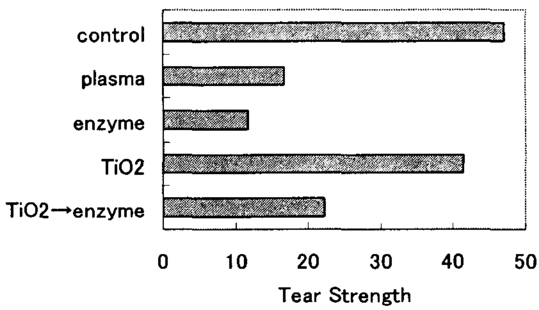

Fig.3 Relation between tear strength and treatments