

Dimensional Stability of Wool Fabrics Treated with Multifunctional Epoxide and Reactive Silicone Polymers

Su Jin Moon and Tae Jin Kang

Dept. of Fiber and Polymer Science, Seoul National Univ., Seoul, Korea

1. Introduction

Among the common textile fibers, wool has excellent wrinkle recovery. However, absorbed moisture plasticizes the structure and increases the rate of stress relaxation during wear deformation. Therefore, the wrinkle recovery of wool deteriorates under very high-humidity conditions and is of particular concern in men's lightweight suits, where the trend is toward wool fabrics of lightweight and bright color in which the wrinkles are emphasized. Various chemical treatments have been routinely applied in the processing of wool fabrics and it is very important for wool fabric, as it alters performance properties.

Multifunctional epoxide reacts with keratin fibers, such as wool and silk, in concentrated salt solutions. The epoxide crosslinks with amino acid residues of keratin fibers, e.g., amines, alcohols, phenols, thiols, carboxylic acids, and so on, thus improving fabric performance properties, such as shrink resistance and wrinkle recovery [1-4].

Silicone polymers are used in textile processing as bath additives to improve fabric hand. In general, silicone textile softeners are classified as nonreactive, conventional reactive, and organofunctional reactive types. Among these, organofunctional silicone polymers contain organofunctional groups, such as vinyl, epoxy, mercapto, or amine, which react with other organic substrates and give durability. Improvement of wear comfort with a bulky and smooth hand, wrinkle recovery, and physical properties depends upon the molecular weight and type of the functional group of the silicone polymers [5-7].

In this experiment, the dimensional stability of wool fabric that has been treated with a simple pad-dry-cure process using glycerol polyglycidyl ether, a multifunctional epoxide, and/or silicone polymers was investigated to achieve better performance properties. In addition, the changes in physical property, such as abrasion resistance, tensile strength, and tear strength, and fabric hand with the application of chemicals were investigated.

2. Experimental

2.1 Materials

A 100% wool plain-weave worsted fabric was used for all experiments. The glycerol polyglycidyl ether (Denacol EX313) was obtained from Nagase Chemicals Co. Ltd. Aminofunctional

polydimethylsiloxane emulsion (DC108) from Dow Corning and epoxyfunctional polydimethylsiloxane emulsion (UNION CARBIDE LE9300) from Organo Silicone. All other chemicals were of reagent grade and used without further purification.

2.2 Fabric Treatment

Liquors containing epoxide, silicone polymers, catalyst, wetting agent, and other bath additives were prepared. Epoxide or silicone polymers were applied alone and a mixture thereof was also applied using a liquor ration of 30:1. Sodium chloride and sodium metabisulphite were added to all liquors containing an epoxide. When epoxyfunctional silicone polymers were applied alone, organotin catalyst was used. Fabric samples were treated with a pad-dry-cure process. After treatment, the fabrics were rinsed with fresh water and air-dried. Treated samples were stored under standard conditions (21 °C and 65% RH) before other properties were evaluated.

2.3 Evaluation and Analysis of Treated Samples

X-ray Photoelectron Spectroscopy (ESCA) : Surface analysis by electron spectroscopy for chemical analysis (ESCA) was carried out using ESCA MK II (LVG Scientific Ltd.) by irradiating a sample with monoenergetic soft X-rays and analyzing the energy emitted by electrons.

Scanning Electron Microscopy (SEM) : Surface modifications to the treated wool fabrics were evaluated using a scanning electron microscope (JEOL Ltd., JSM-35) after they were coated with gold.

Wrinkle Recovery Angle : Dry and wet wrinkle recovery angles were measured according to AATCC Test Method 66-1978 and reported as the sum of both warp and fill directions.

3. Results and Discussion

3.1 Crosslinking of wool with epoxide

The multifunctional epoxide acts as a crosslinking agent. Thus, the changes of mechanical behavior of wool treated with epoxide are largely caused by structural changes such as formation of crosslinks. It is thought that the crosslinks are formed between the adjacent wool molecules and of hydrogen bonds between the hydroxyl groups of the epoxide molecules attached to the side chains such as lysine, arginine, aspartic acid, glutamic acid, and tyrosine residues. Based on the results of the solubility test and SEM, we therefore confirmed the crosslinking of wool fabric with epoxide [8].

3.2 Reaction of wool with silicone polymers

Until now, organofunctional silicone softeners containing only silanol groups or epoxy functional groups were used for wool fabric to give a permanent softening effect, but the reaction with silanol groups is easily hydrolyzed because of the difference in the electronegativity between carbon and silicone. In this study, wool fabric was treated with silicone polymers --aminofunctional polydimethylsiloxane

(AFS), epoxyfunctional polydimethylsiloxane (EFS) and a mixture thereof (AFS/EFS).

Electron spectroscopy for chemical applications (ESCA) is a useful technique for structural and chemical characterization of polymer surfaces. Recently, it has been used to study adhesion, degradation of surfaces, and diffusion of additives. ESCA serves as a valuable tool in elucidating the chemical results of such treatments on polymer surface. Figure 1 shows the X-ray-induced photoelectronic spectrum of wool fabrics. In the treatment of silicone polymers, the peak of Si (2p) was appeared. The binding energy (BE) of Si (2p) were in the range of 100 to 110 eV. Therefore the silicone could be easily detected by ESCA.

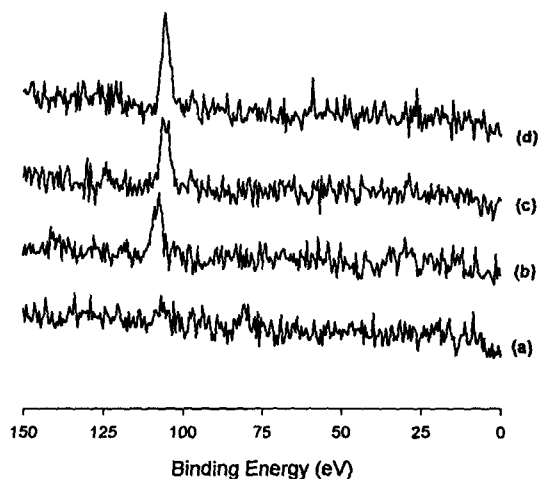


Figure 1. X-ray photoelectron spectra of wool surface: (a) untreated, (b) AFS, (c) AFS/EFS, and (d) EFS treated.

The SEM photographs of wool fabric treated with silicone polymer are shown in Figure 2. Untreated wool fibers have shown a typical scale pattern. But in the treatment of silicone polymers, the scale is coated by silicone polymers. These results suggest that the formation of a thin layer film on the fiber surface by the silicone polymers. Based on the results of the ESCA and SEM, we therefore confirmed the reaction of wool surface with silicone polymers.

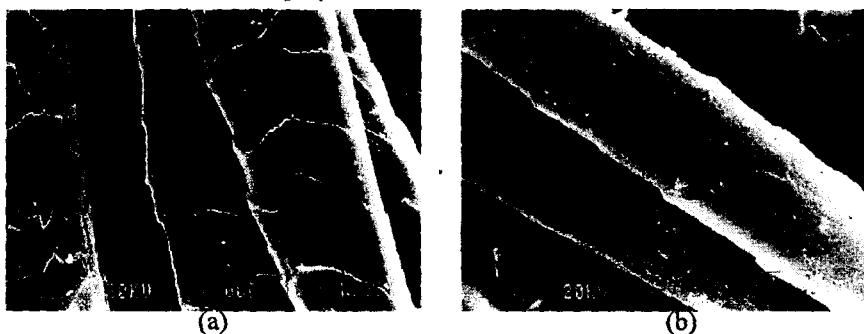


Figure 2. SEM photographs of wool fibers: (a) untreated and (b) silicone polymer treated.

Table 1. The wrinkle recovery angles of wool fabrics treated with epoxide and/or silicone polymers

	WRA (degrees) ^a	
	Dry	Wet
Control ^b	278	255
Epoxide ^c	322	280
AFS	323	268
EFS	320	266
AFS/ EFS ^d	324	270
E-AFS ^e	326	276
E-EFS	325	276
E-AFS/EFS	327	279

^aThe angle was reported as the sum of both warp and fill directions. ^b Mock control sample. ^c 15% owf Epoxide. ^d A mixture of AFS and EFS. ^e A treatment with epoxide and silicone polymer in a two-stage process.

4. Conclusion

The dry wrinkle recovery properties of lightweight worsted fabric can be improved significantly by a simple pad-dry-cure treatment with glycerol polyglycidyl ether and silicone polymers applied alone or simultaneously. The cross-linking agent, an epoxide, acts largely by changing the viscoelastic properties of the fibers, thus increasing their ability to recover from deformations. This contrasts with the action of silicone polymers, which improves wrinkle recovery by decreasing the frictional coefficient, through the formation of a thin layer film on the fabric surface. Furthermore, with silicone polymers, other performance properties, especially abrasion resistance and fabric hand, are significantly improved.

5. References

- 1) H. Ito, Y. Muraoka, R. Umehara, Y. Shibata, and T. Miyamoto, *Textile Res. J.*, **64**, 440 (1994).
- 2) Y. Muraoka, H. Ito, R. Umehara, Y. Shibata, and T. Miyamoto, *Textile Res. J.*, **64**, 514 (1994).
- 3) Y. Tanaka, and H. Shiozaki, in "Proc. 7th Int. Wool Text. Res. Conf., Tokyo," Vol.4, pp.441 (1985).
- 4) R. Umehara, Y. Shibata, H. Ito, M. Sakamoto, and T. Miyamoto, *Textile Res. J.*, **61**, 89 (1991).
- 5) M.M. Joyner, *Textile Chem. Color*, **18(3)**, 34 (1986).
- 6) A. J. Sabia, *Textile Chem. Color*, **27**, 79 (1995).
- 7) M.S. Kim, S.J. Moon, K.H. Oh, and T.J. Kang, *J. of the Korean Fiber Soc.*, **33(6)**, 505 (1996).
- 8) S.J. Moon and T.J. Kang, *Textile Res. J.*, in printing (1998).