

# Comfort Finishing on Synthetic Fibers

Ryu, Hyo-Seon

Dept. of Clothing & Textiles, College of Home Economics, Seoul National University

## 合成纖維에의 Comfort 加工

柳 孝 仙

서울대학교 家政大學 衣類學科

### Abstract

이 解說文에서는 최근 수년간 개발된 合成纖維에의 Comfort 加工 : Polyester 섬유에의 촉감 改善, 疎水性 섬유에 있어서 親水性을 향상시키기 위한 化學的인 처리, 대전방지 가공, 오염방지 가공, 그리고 柔軟화에 대한 것은 문헌조사를 통해 소개하고 있다.

### INTRODUCTION

The main factors that influence the comfort of clothing are thermal protection, moisture transmission, air permeability, hand, sensitivity to contact skin, and static charges. These factors depend upon the several fabric and fiber properties which are chemical and structural. Among these are hydrophilicity, wettability, water wicking properties, electric staticity, flexibility, smoothness of fabric surface, porosity, and bulkiness.

Cotton and wool have some comfort disadvantages such as stiffness of hand on durable press finished cotton or dimensional stability in wool. However, in this paper, I'll concentrate on synthetic fibers because these fibers have inferior clothing comfort factors compared to natural fibers.

When one considers the finishing of synthetic fiber, it's hard to tell the roles of softener, soil-release finishing, anti-static finishing and increasing hydrophilicity finishing. The principles and application of those finishings are interdisciplinary and it is hard to determine their boundary.

Therefore, in this paper, I grouped those finishings by their original titles. Among the physical and chemical finishings on synthetic fiber, I'll introduce only some recent developed chemical finishings on synthetic fiber.

### Recent Development of Comfort Finishings on Synthetic Fibers

#### I. Polyester Fibers Having Wool-like Hand.

Crimped bicomponent polyester staple fibers have a hand similar to wool when a crimp contraction is less than 60% and at least 7 crimp half waves/cm.

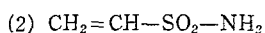
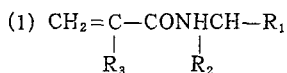
One component of such fibers makes up 50~80% by weight. This is crosslinked polyethylene terephthalate having 0.2~0.7 mole percent of cross-linking agent and an intrinsic viscosity of about 0.45~0.60. The other component of such fibers makes up 50~20% by weight is a sparingly cross-linked polybutylene terephthalate having 0.2~0.6 mole percent of cross-linking agent and an intrinsic viscosity in the molten state at 260°C less than

4000 poises. The cross-linking in both cases-linking agent containing 3 or 4 ester forming groups. Examples of such agents are trimethylolpropane, phloroglucinol and hydroxyhydroquinone, which are polyols; trimesic acid, pyromellitic acid or anhydride, which are acids; hydroxyisophthalic acids and aminoisophthalic acid. The extrusion or spinning temperatures between 260~295°C. The extruded bicomponent fiber is steam drawn at 80~100°C at a draw ratio of about 2.6 to 3.3x and then crimped at a temperature between 100°C and 150°C.

With the fibers produced by this method, it is possible to reduce the wool content of polyester/wool blends without unduly affecting the hand of the resulting fabric. Furthermore, fabrics made from these fibers, either in the pure form or in blends with a low wool content, exhibit a slight elasticity of both warp and weft. In addition, this elasticity facilitates the various steps involved in making such garments, such as sewing, fit, seam cleanliness, etc.<sup>4)</sup>

## II. Processes to Improve Hydrophilicity of Fibers

Processes for improving the hydrophilicity—the water absorbing capacity and absorptivity—of fibrous material (polyester, polyamide or polypropylene) comprise applying modified, highly absorbing cellulose ethers onto these fibrous materials. Fixing is thus developed<sup>5)</sup>. The cellulose ethers such as carboxymethyl cellulose, carboxymethyl-hydroxyethyl cellulose, methyl hydroxy ethyl cellulose, or hydroxy-ethyl cellulose, are modified with a compound of formulas (1) and (2).



where R<sub>1</sub>: —OH, alkanoyl-amino or alkoxy-carbonyl-amino

R<sub>2</sub>: —H or carboxy

R<sub>3</sub>: —H or CH<sub>3</sub>

The modified water soluble cellulose ethers are padded and dried on fibrous material and show

the more than 10 times increment of water absorption of fabric.<sup>5)</sup>

Gorrafafa<sup>6)</sup> saponified and tested the several types of flat and textured Dacron yarns and fabrics to identify relative response of fibers and fabrics to different treatment conditions in terms of temperature, time and caustic concentration by using caustic hydrolysis. He found: "Weight loss increases with increasing reaction temperature, caustic concentration and reaction time, in that order of relative importance. Flat and textured yarns respond in the same general way but may differ in magnitude of the response. Relative fiber strength loss is greater than its corresponding relative weight loss, leading to declining fiber tenacity. The decline in tenacity is moderate in flat yarn but higher in set textured yarn."

"The use of quaternary ammonium compounds as reaction accelerants is quite effective, yielding much higher weight loss than that generated without it. But the advantages of using an accelerant (less caustic and shorter time) is counterbalanced by its detrimental effect on strength degradation."

"The caustic treatment provides greater fabric matrix freedom which, in addition to denier reduction, contributes to woven fabric softness and liveliness. Each fabric is a case by itself for which treatment conditions and optimum results have to be defined. The highest impact of the treatment is in topweight textured wovens; certain fiber types show greater response than others."

Though he didn't mention the hydrophilicity of Dacron, the method described must be one way of increasing hydrophilicity of polyester. The hydrophobic properties of synthetic fiber is the main reason why the synthetic fiber has lower clothing comfort properties. Therefore, increasing the hydrophilicity of synthetic fiber is the most important key to improving the comfort factor of synthetic fibers and fabrics.

## III. Anti-static Finishings

Most natural fibers are composed of strongly

H-bonding polymers and exhibit hygroscopicity. However, some synthetic polymers such as polyolefins, polyamides, polyesters and polyacrylonitriles are comparatively hydrophobic. The problems caused by the accumulation of static electricity on insulating materials and especially on textiles containing synthetic fibers.

Static charges occur for two reasons. (1) Static charges generate when moving fibers or yarns are detached from the contacting surface. (2) Static charges move toward air when the field force exceeds the dielectric force of air, because of the build up of charges on the fiber surface. Static charges cause three main problems: (1) strong, disagreeable shocks caused by the rapid discharge of accumulated static electricity; (2) attraction of dust from the atmosphere to the fabric to form solid spots thereon; and (3) detriment to the functioning of sensitive electronic equipment because of static-electricity discharges.

There are three general ways to solve those problems: (1) use of highly conductive threads or fibers as the textile material; (2) incorporation into the fabric of very fine steel wires; or (3) application of chemical anti-static agents to coat the fibers. To provide the static protection for synthetic fibers, there are three approaches current in practice: (1) surface treatment, (2) copolymerization, and (3) internal antistats.<sup>7,15)</sup>

#### Internal antistats

Internal antistats have polar groups oriented toward the external surface of a polymer, thus forming a conducting layer on the polymer exterior which will reduce the electrical resistance and accelerate the dissipation of electrostatic charges. The antistats embodied in the polymer remain active after extrusion without impairing the bulk properties of the polymer. The following are various internal antistatic agents compared with regard to advantages and limitations when used on specific fibers.

#### Polyamide fibers

1. Poly(alkyleneether) glycol. Polyamide polymers are rendered antistatic by incorporating 15%

of a high molecular weight polyethylene glycol (mol. wt. 20,000). Use of low molecular weight glycol is avoided for two reasons: (1) interference in polymerization, (2) ease of removability.

2. Ethoxylated triglycerides. These are commercially used as internal antistats for BCF carpet nylon. Ethylene oxide adducts of hydrogenated castor oil are the preferred compounds because of ready availability of castor oil in highly purified form.

3. Dialkylamine-polyether. Distearylamine-polyether imparts antistatic effectiveness resistant to more than 25 washings. Straight alkyl chains, rather than the branched type, are preferred to minimize the effect on other fiber properties. Amine derivatives are, however, prone to discoloration from thermal oxidation and light.

4. Polyamide (polyether) phosphates. Caprolactam polyoxyethylene ethanol triphosphates-synthesized by reacting with phosphorus oxychlorides were used as internal antistats at about 15% owp concentration levels. The use of phosphate esters results in fewer filament breaks during processing than does the use of alkylene (polyether) glycol.

5. N-alkyl polycarbonamides. N-alkyl polyhexamethylene dodecanediamide effectively promotes the resistance of nylon to static development.

#### Polyester fibers

1. Polyethylene glycol diacetate or dibenzoate is utilized as an antistat. PEG 9,000 dibenzoate is preferred, showing maximum antistat response with minimum soiling propensity. 3-nonylphenoxypropane sulfonic acid potassium salt dispersed in polyethylene glycol 20,000, when incorporated in the polymer matrix, exhibits pronounced antistat-effect without complicating polymer processing. (The numbers, for example 9,000 and 20,000, are the molecular weight of the compounds.)

2. Amphoteric surfactants based on alkyl amine salts are frequently effective internal antistats. However, they are prone to discoloration on exposure to elevated temperatures.

3. Hexyl- or benzyl-glycidylether treated fibers show good efficacy retention after repeated wasa-

ings.

### Acrylics

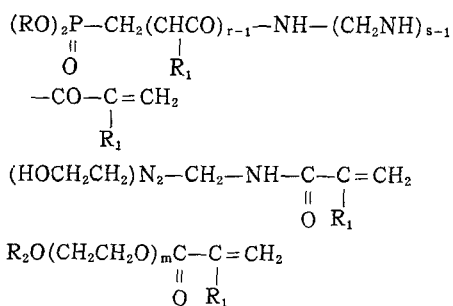
1. A quarternary hydroxyamine ester such as glycidyl stearate, reacted with diethyl sulfate, is an excellent antistat for acrylics. It possess good thermal stability and resistance to discoloration under fiber processing conditions.

2. Alkoxyated polyamides provide static protection which is durable through 25 wash cycles.

3. Methoxy-polyether-acrylate imparts good anti-static properties to acrylic fibers, but lacks durability to repeated washings.

### Copolymerization

Second, copolymerization is a method of finishing synthetic organic fibrous material with an anti-static finish and simultaneously improving the dirt repellency. This method consists of treating and material with aqueous or organic solutions or emulsions which contain at least one copolymer derive from at least two of the monomers of formulae.<sup>9)</sup>

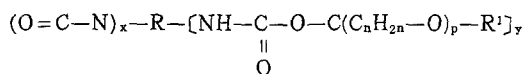


where R is straight-chain or branched alkyl of 1~8 carbon atoms, R<sub>1</sub> is H or methyl, R<sub>2</sub> is alkyl of 1~6 carbon atoms, m is an integer from 6~15, and each of r and s is 1 or 2

This copolymerized synthetic fiber shows a permanent antistatic effect. The anti-soiling effect and also the fastness to rubbing and light and the soft handles are not impaired by this finish.

### Binders

Third, there is an antistatic treatment for synthetic fibers held together by a binder which includes a urethaneaklyene copolymer of the formula.<sup>9)</sup>



where R is an aliphatic and/or aromatic moiety which contains biuret groups, urethane groups or isocyanate groups, R' is the group consisting of H, C<sub>1</sub>~C<sub>8</sub> straight or branched chain alkyl, aryl or alkyl, x is 0~1, y is always greater than 2, n has a value of 1~4 inclusive and p is greater than 5.

The best result is obtained where the thermo-sensitive product is utilized in the presence of a latex composition containing a hydrophilic group therein.

### IV. Soil Release Finishing

The soiling of textile materials is one of the most difficult problems associated with their use. Particulate soiling of synthetic fibers is generally due to the static attraction of soil from a dust-laden environment. Greasy soiling which is also encountered during laundering, occurs due to the hydrophobic nature of synthetic fibers.

Most soil release and soil release finishes operate by increasing the polarity or hydrophilic properties of the fiber surface. They do this by reducing the surface energy of the fiber or by modifying the surface structure physically so as to reduce surface irregularities of fibers. Soil release finishes increase the hydrophilic character of synthetic fibers needed for increased fabric comfort in warm, humid conditions. They impart antistatic properties, increase moisture absorbance and improve water transport and wicking to synthetic fabrics for improved comfort and washability. Soil release finishes thus act as 'fabric conditioners'.

Soil release finishes are generally classified into three classes: (1) acrylic polymer finishes, (2) fluoropolymer finishes and (3) oxyethylation products of polymers.<sup>10)</sup>

Methacrylic acid monomer is used as soil release agent on cotton and cotton/polyester blend.<sup>11)</sup> The main object of this patent is to provide a single-treatment process for imparting durable soil release properties to cotton and cotton. P.E. blend fabrics with different construction and compositions. Another object of this is to increase the capacity of these textile fabric blends to absorb and transmit

Table 1. Effects of PMMA\* on Cotton and Cotton/P.E. Blends

Fabric Composition and Construction	Moisture Regain %	PMMA Add-on %	Soil Removal Efficiency Aqueous soil	% Oily soil
all cotton fabrics	6.12	0	31	48
100% cotton warp	6.77	15	64	75
100% Cotton fill	7.00	22	98	69
75% cotton fabric	5.24	0	53	55
100% cotton warp	5.81	9	86	70
50% cotton fill	6.17	17	98	74
50% P.E.				
75% cotton fabric	3.93	0	46	53
50% cotton warp	4.50	7	87	71
50% P.E.				
100% cotton fill	5.40	18	84	71
50% cotton fabric	3.11	0	52	60
50% cotton warp	3.70	6	94	71
50% P.E.				
50% cotton fill	4.10	8	96	71
50% P.E.	4.38	10	92	74

\*PMMA: Polymer of Methy Methacrylic Acid

more water vapor, that is, to increase the water regain properties. The procedure has four parts: (1) irradiating the cotton or cotton/P.E. blend fabric to a dosage of 1 megarad: (2) then, impregnating fabric with a solution 80:20 of methanol. water containing about 2~15% methacrylic acid monomer: (3) reacting the impregnated fabric for about 15~120 mins at ambient temperature (20~28°C), the time varying with the desired degree of graft polymerization; and (4) washing the unreacted chemicals off the reacted fabric and drying it. Table 1 shows the result of this method.

Hayes and Dixon<sup>12)</sup> did a direct fluorination on polyester fiber and their results showed the improvement on moisture transport, soil release, and soil antiredeposition properties of polyester fiber. Also they said that these properties do have the limitations associated with previous treatments such as stability, washfastness, and/or reproducibility. And improved properties of polyester can be attributed to an increase in acidity and to the addition of fluorine to the polymer backbone. The direct fluorination treatment is unaffected by dyeing, heat setting, or ultraviolet light.

#### V. Fabric Softener

An effective softener imparts surface lubricity, flexibility and ease of compressibility to the fabric.

It should lubricate the material in a subtle manner so the anti-static, anti-snagging and smooth, easy-slippage surfaces are achieved. When the fabric softener is well formulated and properly used, fabrics become soft and fluffy, garments shake out easily from one another because of improved surface lubricity and anti-static effects, and they are easily pressed or ironed. Softened fabrics are also more easily sewn and their tear strength can be improved.

Fabric softeners can be grouped into three major classes: anionic, nonionic and cationic. In as much as most fibrous materials carry a negative surface charge, the cationic softeners deposit preferentially on the fabric surfaces.

Usually, dimethyldihydrogenated tallow quaternary ammonium chloride (e.g. Adogen 442), dimethyl dicoco quaternary ammonium chloride and modified imidazoline (e.g. 1-methyl-1-tallow amido ethyl-2-tallow imidazolium methosulfate: Varisoft 475) are used as cationic fabric softener.<sup>13,14)</sup>

Recently the following groups have been developed as fabric softeners:

- (1) aminocarbonamide
- (2) higher alkylamide derived from 2-amino 2-methyl propanol and 2-amino 2-ethyl- 1,3-propanol
- (3) N-alkyl propylene diamine reacted with

maleianhydride and combined with small quantities of sugar or urea, or ethoxylated alkyl diamines

These softeners are compatible with anionic detergents used in home laundering.

Water particulate materials such as surface modified starch, teflon, polystyrene, polymethyl metacrylate and ureaformaldehyde resins are compound with fabric softeners. This kind of softener imparts several beneficial properties to the fabric, for example, anti-wrinkling, ease of ironing, anti-static effects and ease of folding.

Another development involves the controlled-release of the softener in the clothes dryer. The softener is encapsulated in a suitable gum of resin or is absorbed on a polyurethane sponge or nylon strip and melts at a given temperature in the dryer and thereby release the softener at that time to act on the fabric.

Detergents such as ethoxylated alkyl amine or sulfosuccinate compounds formed from polyhydroxy tertiary amines have their own softening properties.

One special significant thing is the reaction product of a bromophosphorous compound with a fatty diamine to produce a softener to impart flame retardant properties. This development has far-reaching implications for sleepwear and other fabrics for which safety consideration are important.

## REFERENCES

- 1) Hollies, N.R.S. & Goldman, R.F. **Clothing Comfort**, Ann Arbor Science Publishers, Inc., Ann Arbor, 1977.
- 2) Fourn, L. & Hollies, N.R.S. **Clothing**, New York, Marcel Dekker, Inc., 1970.
- 3) Sello, S.B.: Functional Finishes for Natural and Synthetic Fibers, *Applied Polymer Symposium*, **31**, pp. 229-249, 1977.
- 4) U.S.P., 4060968
- 5) U.S.P., 4136218
- 6) Gorrafa, A.A.M.: Caustic Treatments of Polyester Filament Fabrics, *T.C.C.* **12**, no. 4, pp. 33-37.
- 7) Nagta, R.: Internal Antistats, *American Dye stuff Reporter*, **64**, no. 4, pp. 41-94, 1975.
- 8) U.S.P., 4066597
- 9) U.S.P., 4164535
- 10) Das, T.K. & Kulshreshtha, A.K.: Soil Release Finishing of Textiles: A Review, *Journal of Scientific and Industrial Research*, **38**, Nov. pp. 611-619, 1979.
- 11) U.S.P., 4063885
- 12) Hayes, L.J. & Dixon, D.D.: A Technique for Imparting Soil Release, Soil-antiredeposition, and Moisture transport Properties to P.E., *T.R.J.*, **47**, no. 4, pp. 277-282, 1977.
- 13) Foley, J.: Recent Developments in Fabric Softener Technology, *Soap/Cosmetics/Chemical Specialities* for July, pp. 25-27, 1978.
- 14) McConnell, R.B.: Softeners & Ethoxylates, *American Dyestuff Reporter*, **67**, no. 7, pp. 31-34, 1978.
- 15) Szego, L.: Modified Polyethylene Terephthalate Fibers, *Advances in Polymer Science*, **31**, pp. 89-131, 1979.