Glow discharge lessens wool's shrinkage

What happens to fibers during treatment in USDA-developed process isn't clear, but may involve free radicals

Most people have lived through the irritating experience of having put a woolen garment through the wash only to have it come out a fraction of its original size. Indeed, wool's inherent tendency to shrink has been a major factor behind the dramatic rise in sales of nonshrinking synthetic fibers at wool's expense. Now, a novel treating process under development at the U.S. Department of Agriculture's Western Regional Research Laboratory in Albany, Calif., greatly lessens this principal disadvantage of wool, and should strengthen wool's competitive position in the market place.

Involved is the passage of yarn through a low-temperature radio frequency (RF) glow discharge. This fairly simple operation heightens wool's resistance to what is known in the fabric trade as felting shrinkage. In addition, there is a noticeable gain in both abrasion resistance and yarn strength without any apparent change in the knitting and weaving characteristics of the yarn, nor in the hand, or feel, of the woolen product. Moreover, the effects seem permanent.

Precisely what happens to the wool fiber structure during exposure to an RF glow discharge still isn't clear, admits Dr. Attila E. Pavlath, who is directing the project. Treated and untreated yarn, he points out, are indistinguishable under the scanning electron microscope.

[illegible]. "One possibility," he conjectures, "is that the effect may be the result of partial cross-linking reactions occurring on the fiber surface because of the creation of free radicals. This would help explain why [illegible] suitable for chemical [illegible] at the time of the treatment [illegible] at the F[illegible] technical conference in [illegible] glow discharge neither affects the yarn's dyeability nor improves retention of dye applied after the operation—an indication that surface free radicals created by plasma activation do not survive long afterward."

Dr. Pavlath, with coworkers Richard F. Slater and Kay Lee, has devised a simple reactor for studying continuous glow discharge treatment of yarn. Capillary tubing, connected to the glow discharge chamber and through which the yarn is threaded, maintains the pressure within the discharge chamber at about 3 torr—a satisfactory level for generating and maintaining the glow discharge, provided the relation between tube bore and yarn diameter is carefully selected. Residence time of the yarn in the reactor chamber is varied by changing the speed of the takeup reel.

The USDA scientists have examined the influence of a variety of conditions on the properties of the irradiated yarn and the shrink-proofing of items knitted from it. Temperature variation, for instance, has little effect apart from the danger of scorching or burning the yarn should it become too hot. Nor is the nature of the gas a key factor. Results are much the same whether residual air, oxygen, nitrogen, hydrogen, helium or carbon dioxide is used. The latter phenomenon leads Dr. Pavlath to think that the changes in the wool properties are induced by electrons in the plasma rather than by excited molecular species.

Important. But RF power and the residence time of the yarn in the glow discharge region are important factors. At a discharge power of 10 watts, the area shrinkage of a knitted fabric is 16.5% when residence time is 0.4 second, 12% when residence time is one second. At 30 watts, shrinkage is 9.5% for a 0.4 second residence time, 6.7% after one second. Indeed, zero shrinkage is achieved when RF power is 50 watts and residence time is slightly greater than a second. These figures contrast sharply with the 44.5% area shrinkage that a control fabric, similarly knitted from untreated yarn, undergoes when subjected to a 75-minute, hot-water wash test in a domestic machine along with knitted, RF-exposed wool.

Dr. Pavlath sees important advantages to the glow discharge technique for shrink-proofing wool compared to conventional chemical treatment methods, many of which cause undesirable effects such as losses in yarn strength and changes in fabric hand. One possible criticism that a textile engineer might level at the method, he admits, is that the throughput time of the yarn, at least in the present state of the technique's development, might be rated slow for an industrial operation. Offsetting such a criticism, Dr. Pavlath points out, is the fact that multiple strands can be drawn through the discharge simultaneously.

As part of the ongoing development program, Dr. Pavlath and coworker Merle M. Millerd are looking into the possibility of chemically treating wool to make it soil resistant at the same time that it is being shrinkproofed. It might be possible, for instance, to use the glow discharge to induce grafting of atoms or groups onto the fiber surface.

USDA's Attila E. Pavlath