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Olney Medal Address

Hydrophilic Soil Release

By DMITRY M. GAGARINE, Milliken Research Corp., Spartanburg, S. C.

LADIES and gentlemen, I am deeply appreciative of the great honor which you have bestowed upon me by presenting me with the most coveted award in the world of textile chemistry, the OLNEY MEDAL.

Most of my professional life I have been fortunate in being able to surround myself with technical people who are smarter than I and whose skills are far greater than mine in many areas. In awarding me this cherished medal you really honor the men and women who have worked with me and who have made the accomplishments possible in the laboratory, in production and in marketing. Without their creative contributions and their hard work, none of it would have been possible.

Since the OLNEY AWARD is such a special occasion, instead of presenting a technical paper I just want to share with you some pleasant memories, some experiments, and a few conclusions reached along the path leading to hydrophilic soil release fabrics.

Hydrophilic And Hydrophobic Fabrics

First I want to focus your attention on the adjective "hydrophilic" and tell you about some experiences with hydrophilic and hydrophobic fabrics worn next to the skin.

When resinated cottons were first introduced, it was apparent to some of us that they were not as comfortable as untreated cottons. Discomfort was more pronounced under hot, humid conditions and increased with increasing crease resistance. Since highly resi-

nated fabrics tended to feel more scratchy and rougher than untreated cottons, it was reasonable to try to make them softer by incorporating durable softeners.

In those days, the most effective durable softeners were stearamidomethylpyridinium salts (1) and silicones. Both types reduced the stiffness of fabrics. They also made fabrics less absorbent.

One late spring, some 30 years ago, I participated in a wear test on resin treated cotton broadcloth shirting with and without the hydrophobic finishes. The finished fabric felt wonderful when it was cool. As it became warmer, however, we could feel droplets of perspiration slowly trickling down our skin. The hydrophobic shirting would cling to the wet skin, pull away and stick again with a cold wet surface. Clearly, hydrophobic finishes gave a negative contribution to comfort in shirting.

There was some discussion among our group about the effect of garment construction confounding the wear test; loose fit versus tight fit and its relation to the observed clinging action. Another wear test was made using tight fitting T-shirts. Nylon filament tricot was selected in order to prevent variations in modulus. One set was treated with silicone water repellent, the other was untreated, clean nylon, reasonably hydrophilic. The experiment was a disaster. Both sets were hot and uncomfortable but the water repellent T-shirts were absolutely awful. They were terribly hot and stuck to the skin, and we spent

ABSTRACT

A variety of approaches used in the development of cotton fabrics with soil release and self-ironing properties are reviewed. The hand of resin treated cotton fabrics was improved by hydrophobic and hydrophilic finishes. Such finishes were not successful for fabrics intended to be worn near the skin because of the reduction of the moisture wicking properties. Cotton fabrics crosslinked with epichlorohydrin showed high wet resiliency and soil release properties.

A somewhat different approach is necessary, but hydrophilic soil release properties can also be imparted to textured polyester and polyester/cotton.

KEY TERMS

Cotton
Durable Press
Finishing
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Polyester
Soil Release

advantages were: a luxurious silky hand, flat drying properties, retention of whiteness, and shrinkage control. You could always tell our products; they looked whiter and fresher than regular cottons. We licensed the process for sheeting, and it went commercial. Diapers did not make it. The market was too small and the cost too high.

Next we focused attention on the shirting market. This was in the days of drip-dry cotton shirts when tumble driers were still scarce. In order to wash a drip-dry shirt so that it would be wearable without pressing, you had to remove it from the washing machine just before the spin cycle grabbed it and wrinkled it. If you did not make it in time, it had to be ironed. Removing soaking wet clothes from a washing machine without spin drying was another challenge. Wet floors, wet feet and endless dripping was the price for no ironing.

In order to have differential advantage in the marketplace we needed: wet resiliency, dry resiliency, soil release and a luxurious hand. It was found that a very light resin treatment of cotton prior to wet crosslinking with epichlorohydrin resulted in a synergistic action (5,6). We obtained more dry resiliency, more wet resiliency and more strength retention than could be reasonably expected, but we lost our soil release advantage. As a matter of fact, we developed a serious problem with stains and with dirt redeposition in laundering.

Don Gardner found that different thermosetting resins behaved quite differently although all of them gave problems with soil retention and soil redeposition in our process (Table I). Stain retention and soil redeposition were closely related.

Table I—Order of Soil Retention and Soil Redeposition

Order	Resin
Greatest	Trimethylol Melamine
	Dimethylol Ethyleneurea
	Dihydroxydimethylol Ethyleneurea
	Carbamates
Least	Formaldehyde

None of the dry crosslinked samples had the beautiful soil release that we had in our wet crosslinking process.

Bill Mauldin found that dirt redeposition in laundering was proportional to staining of the fabrics with acid dyes and advanced the hypothesis that the stain retention and soil redeposition were a function of cationic activity of the finish produced by the reaction of epichlorohydrin with nitrogenous resins. This was a good lead, and it rapidly led us to the addition of anionic polymers, and we re-

gained our lost soil release and solved the redeposition problem.

Carboxymethyl cellulose turned out to be the preferred product. The best point to add it was, strangely enough, in the resin bath, prior to treatment with sodium hydroxide and epichlorohydrin.

This was the process for producing Belfast self-ironing fabrics, and the process succeeded in the market place against wash-and-wear cottons despite its greater complexity and higher cost. It is wonderful what a differential advantage can do in a highly competitive situation.

Polyester/Cotton Blends

Then came polyester/cottons. The above process was not applicable because polyester retained epichlorohydrin.

Stain retention and redeposition problems were serious on resinated polyester/cotton fabrics. The soil release agents that worked so well for us before did not work on polyester/cottons.

Frank Marco tackled the problem and came up with a good solution. Acrylic ester copolymers containing acid groups could be added to the thermosetting resin bath to give good soil release together with durable press properties (7).

A great deal of work was done in optimizing the compositions and application methods to make the products durable for the life of the fabric (8,9). Industrial laundering conditions of pH 11.0 and temperatures of 180F were a real challenge, but this too was overcome.

Hans Kuhn, Phil DeMott, Jack Lynch, Bob Stoner, Randy Mosley, Oscar Fuller and Greville Machell invested many years in this work and their efforts resulted in a substantial business in soil release durable press polyester/cotton fabrics (10).

Textured Polyester

In the last four years, textured polyester fabrics have become increasingly important. Textured polyester fabrics are wonderful products. Garments made from them are strong and last a long time. They resist wrinkling, keep their creases and have good wash-and-wear properties. However, ordinary polyester fabrics have a few problems. They are hydrophobic and do not transport perspiration effectively. They are oleophilic, and as a result oily stains do not come out readily in the wash, frequently leaving the garments with visible stains. Oleophilic properties also are responsible for soil redeposition problems in laundering.

Finishes and fiber modifications which impart hydrophilic properties and soil release have been reviewed several times in the literature (11-19).

To demonstrate hydrophilic soil release performance, you know that hydrophilic textured polyester removes the liquid layer between fabric and skin and does not stick the way ordinary polyester does. If we stain both fabrics with olive oil and immerse them into a detergent solution at a concentration recommended on the detergent package, in water at room temperature, ordinary polyester remains stained. Oil clings to it tenaciously. Textured polyester with hydrophilic soil release, however, is preferentially wetted by water. Oil separates from it, rolls up into globules and floats away, leaving the fabric clean.

If we then take the wet samples from the previous experiment and place them in a quart jar a third full of detergent solution previously used, add 5 ml of #4 fuel oil and shake for about 30 seconds to simulate a very dirty wash, ordinary polyester, being oleophilic, picks up a lot of dirty oil and turns dark. The olive oil stain from the previous experiment remains through the vigorous agitation.

The hydrophilic soil release sample, on the other hand, is preferentially wetted by water. The forces required to displace the water and wet it with oil are much greater than those available; therefore, the fabric stays white.

Another useful property of hydrophilic soil release polyester is the ability to remove stains from a garment while wearing it. Just rub it with a paper towel wetted with water and soap or a detergent, and the stain comes out.

In conclusion, soil release properties help in the ease of care of garments; hydrophilic properties contribute to comfort under warm conditions. ☺

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