Cross-Linking Cotton

Ruth Benerito is not a household name, but her chemistry is.

She is the Agricultural Research Service chemist who led the team that invented the process that created permanent press. This, in turn, gave rise to a whole school of chemical textile treatments and essentially kept cotton on the apparel-retailer's shelves. The legacy of her work is still prompting research and producing new benefits.

"Wash and wear" treatment of cotton came along in the nick of time after World War II. Synthetic fabrics like polyester were rapidly gaining market share at the expense of care-intensive cotton. Not needing to be ironed brought cotton back to popularity.

"Take trousers—they represent the largest single apparel market for cotton today. I estimate that when we exclude jeans, more than half of all men's, boys', and ladies' trousers are made from durable-press-treated fabrics," says Andrew Jordan, former vice president of technical services for the National Cotton Council.

The process Benerito's team developed is based on treating cotton fibers with reagents that strengthen the hydrogen bonds between chainlike cellulose molecules—a process called "cross-linking." The result is a cotton fabric that does not readily wrinkle. Later she refined the process into durable or permanent press, which brought the added benefit and convenience of permanent creases to cotton garments.

But the process had many more possibilities than just foiling wrinkles.

"The chemistry is basically a way to attach organic chemicals to cotton fibers. Once Benerito worked out the method of attachment, you could use it to add valuable properties other than wrinkle resistance. And we have," explains Brian Condon, research leader of the Cotton Chemistry and Utilization Research Unit, the current iteration of Benerito's lab. The unit is located in New Orleans, at the ARS Southern Regional Research Center (SRRC).

One of the direct descendants of Benerito's work was a cross-linking treatment to make cotton flame retardant. The coating has been used on children's sleepwear, mattresses, and upholstery, as well as on uniforms for firefighters and the military.

While working in the 1950s at the ARS laboratories in New Orleans, Ruth Benerito developed a key process that led to permanent-press cotton and stain- and flame-resistant fabrics.

That coating was turned over to industry in the early 1960s and served as the industry standard through the 1970s. The treatment continues to be used on upholstery and mattress batting. For clothing, other treatments and synthetics have superseded the ARS treatment.

"The original chemistry research was done, and everyone believed that was that," Condon says. "But higher standards for fire retardancy are currently being written, and they've caused renewed interest in cotton treatments." Condon is in the early stages of research on a promising new fire-retardancy treatment for cotton.

Benerito's discovery has also paved the way for new biomedical treatments for cotton. ARS chemist Vince Edwards has developed a cotton medical dressing treated to sequester proteases, destructive enzymes that collect in and prevent healing of chronic wounds.

"We used the cross-linking chemistry as a way to incorporate negatively charged ionic modifications into cellulosic cotton fibers, which pull the positively charged proteases up and away from the wound," Edwards explains.

Edward's dressing has been licensed to Tissue Technologies in Richmond, Virginia. To bring the product to market at a competitive price, they still need to increase the speed of impregnating the fibers.

Edwards is also working on a treatment that will give cotton a superior ability to clot hemorrhaging wounds. He has developed a method for more uniformly embedding hemostatic agents like chitosan—a shrimp-based compound that is a natural clot promoter.

"Think what a wound dressing or even a uniform that stops bleeding in a hemorrhaging wound would mean on the battlefield or in the emergency room," Edwards says.

He is currently discussing a cooperative research and development agreement with

a company to bring a product to market.

SRRC scientists are also considering trying to develop a cross-linking-style treatment to improve cotton's ability to wick moisture away from people's skin.

"Such a treatment could open up a major new market for cotton athletic clothes, an area of apparel currently dominated by synthetics, which have the best wicking abilities right now," Condon says.

Another way to improve cotton would be a treatment to improve its drying time. "Think of the reduction in energy costs if you could treat cotton so it needs 10 or 15 minutes less in the dryer. Hotels, restaurants, any business that is linens intensive would save a lot of money," he says.

"And it's all a legacy of Dr. Benerito's work."—By **J. Kim Kaplan,** ARS.

This research is part of Quality and Utilization of Agricultural Products, an ARS national program (#306) described on the World Wide Web at www.nps.ars.usda.gov.

Brian D. Condon and J. Vincent Edwards are in the USDA-ARS Cotton Chemistry and Utilization Research Unit, Southern Regional Research Center, 1100 Robert E. Lee Blvd., New Orleans, LA 70124; phone (504) 286-4540 [Condon], (504) 286-4360 [Edwards], fax (504) 286-4390, e-mail brian.condon@ars.usda.gov, vince.edwards@ars.usda.gov. ✸

SCOTT BAUER (K4549-1)

The invention of durable press helped the cotton fabric industry reinvent itself after World War II.

Ruth Benerito— Landmark Chemist

Ruth Benerito, who developed a key process in durable-press cotton, created landmarks throughout her life. She was one of only two women allowed to enroll in chemistry class when she attended Tulane University. She then went on to earn her Ph.D. in chemistry from the University of Chicago.

Benerito became a research leader at ARS's Southern Regional Research Center (SRRC) in her native New Orleans at a time when few women were working in science. But she wasn't thinking of women's liberation when she led the team that freed women from the drudgery of the ironing board with the creation of a coating that cross-linked fibers and made cotton wrinkle resistant.

"I was just interested in the application of physical chemistry to solve practical problems," she explained in an interview taped when she was inducted into the ARS Hall of Fame in 2004.

The significance of her permanent-press process was publicly acknowledged when she was inducted into the National Inventors Hall of Fame in 2008, one of only six women to have ever been so acclaimed. She also was the first female recipient of the prestigious Southern Chemist Award and was honored by the Massachusetts Institute of Technology's Lemelson-MIT Lifetime Achievement Award in 2002.

But Benerito's accomplishments went far beyond fighting wrinkles in cotton. She received more than 55 patents in her 33-year ARS career, including one for developing a fat emulsion that could be used in intravenous feeding of patients.

Benerito's work and subsequent SRRC research on cotton treatments led the American Chemical Society to name the center a National Historic Chemical Landmark.—By **J. Kim Kaplan,** ARS.

"Wash and wear" treatment of cotton came along in the nick of time after World War II. Synthetic fabrics like polyester were rapidly gaining market share at the expense of care-intensive cotton. Not needing to be ironed brought cotton back to popularity.