One of the oldest fibers to be made into fabrics, wool has a long history and rich traditions. "Wool has been with us for a long time. There are 25,000 years of known history of this fiber," says Crisan Popescu, of the German Wool Research Institute (DWI an der RWTH). For much of that history, people have been wearing garments and using textile products made of wool.

Wool is a fabulous fiber, say all the experts. Wool fabrics boast a soft hand, excellent drape and crease recovery, odor absorption, breathability, natural flame resistance, natural antibacterial properties, excellent breathability, and take dye readily. The fiber has naturally built-in elasticity due to coiled proteins, according to David Lewis of the University of Leeds, and "can absorb its own weight in moisture without feeling wet."

"The outdoor industry is in love with wool as a natural substitute for synthetics," notes Jim Heiden of Teko Socks. Wool can keep wearers cool on a hot day and warm on a cool day, and retains its warmth even when it is wet. "Wool's remarkable properties for resiliency, warmth with comfort, the ability to control the microenvironment of the wearer, and more, including unique aesthetic appeal, will be perennially appreciated by the consumer," says Jeanette Cardamone of the U.S. Department of Agriculture (USDA).

With all its wonderful features as a fiber, why isn't wool more popular? According to Popescu, the amount of wool consumed globally today is about the same as it was in the 1950s and 1960s. "The demand for wool is constant, but wool is only about 2.5% of all the fibers in the textile market,"
says Popescu. So, what’s wrong with wool?

For all its uniqueness and wonderful properties, in many ways wool is a fiber of limits. Advances made in the wool sector of the textile industry often involve a struggle to overcome those limits.

**WHAT’S WRONG WITH WOOL?**

**Limited Production**

One of the limits imposed on wool is a natural limit because wool is a natural fiber. “Sheep produce five to six kilos of wool per year,” notes Popescu. “To produce this wool, the sheep have to be fed. Two sheep require about one hectare for pasture. Thus the need for pasturage limits the amount of wool that can be produced.

If you wished to replace all the other fibers currently being produced with wool, you would need about 100 million square kilometers of good pasturage for all the sheep. So there is a natural limit on how much wool fiber you can produce.”

Even if there was a sudden miraculous increase in land available for pasturage, there’s no guarantee it would be used to increase wool production. “Land is valuable,” notes Klaus Hannemann of Ciba Specialty Chemicals. “There is competition for acreage. Often, more profitable things can be done with the land, and the sheep farmers are competing for it.”

Moreover, even if the sheep farmers own sufficient acreage, it might not be profitable to produce the wool anyway. “Farmers aren’t making enough money to grow wool right now,” notes Heiden. “We need fair pricing. We need to pay farmers enough to both run their farms and enable them to innovate so that they can produce a better fiber.”

**Price**

In part because of the limited production, wool is an expensive fiber. “Wool costs three to five times as much as other fibers,” notes Hannemann. Lewis agrees that the limits of wool are an economic problem, not a technological one. “The industry just can’t produce enough, cheaply enough.”

Allan De Boos of Australian Wool Innovation (AWI) agrees that “Wool is an expensive raw material compared to synthetic fibers and cotton. It is also more expensive to process. The costs tend to keep it out of very price sensitive markets.”

**MISPERCEPTIONS**

One of the limitations of wool involves consumer perceptions. “Many countries don’t take wool seriously as a fiber,” notes Popescu. “There is a strong relationship between consumed wool per person and a country’s gross domestic product (GDP). The GDP for the highest wool importing countries is at least $5,000/person. The United States is a ‘cotton country’ and uses less wool than is typical for their GDP, but other developed countries like Japan and the United Kingdom are more typical in their wool consumption.”

Additionally, “Wool is a very traditional fiber and has an old-fashioned image,” notes Hannemann. “Wool coats are being replaced by lighter weight synthetics. Formal clothes have been replaced by casual wear. The prevalence of central indoor heating has meant that there is no need for heavy sweaters. The trend is also towards lighter weight fabrics, which means that less wool is used in the fabrics.”

Consumers also worry about caring for wool garments and are concerned that they will felt or shrink in the wash. However, today garments are available in both 100% wool and wool blends that are machine washable. The Woolmark brand certifies machine washable and tumble dryable garments as “Total Easy Care.”

“One myth needs to be dispelled,” says De Boos. “Wool is not scratchy. That’s not modern wool. Only wool containing a significant amount of fibers coarser than 30 microns is scratchy next to the skin. Fine wool has a luxurious soft hand. Consumer perceptions of wool being scratchy were brought on by the use of coarse grade fibers that aren’t suitable for garments.”

“Fineness is all important,” Lewis agrees. “Fabrics made from fibers less than 21 microns can be worn next to the skin and are superbly soft.”

**Processing Issues**

Modern wool processing is focused on dealing with wool’s tendency to felt, shrink, and pill, and with taking advantage of wool’s dyeability.

Since wool is a natural fiber, it must
be scoured prior to further processing. Besides various detritus from the pasture, sheep’s wool has lanolin, which has to be removed during the scouring, according to Lewis. The effluent from wool scouring can be very polluting.

In the 1960s, CSIRO’s Division of Textile Industry, now Textile and Fibre Technology, developed the Chlorine-Hercosett shrinkproofing process to prevent wool from felting and shrinking during machine washing. The chlorine used in the Hercosett process also leads to hazardous effluent, which is banned in many countries.

According to Hannemann, afterchrome dyes are often used to dye wool, especially for navy and black shades (25-30% of the wool market share). The dichromate used in this process is not only regarded as a potential health hazard during processing, but also leaves chromium in the effluent – the amount of chromium is restricted by many countries. According to Lewis, dyeing wool above the boil also damages the fibers themselves.

## FINDING SOLUTIONS

### Sustainability

Since wool is a natural fiber, and a renewable resource, it’s not a big stretch to see it join the movement towards sustainability. “Wool is a clean green fiber,” says De Boos.

Heiden uses sustainably farmed wool to make his company’s products. “Holistic sustainable wool farming is certainly possible,” he says. “The big issue with wool in how it is raised is proper grazing and farm management. We get our wool from a holistically sustainable sheep farm in Tasmania. They are working to return the native grasses to their land and they rotate the sheep so that no sheep is on the same portion of land for more than half a day.”

### Environmentally Friendlier

Producing wool in an ecological way is just one step. Finding solutions to many of wool’s processing issues means finding ways to make wool processing more environmentally friendly. “There is a promising market in the sustainable wool processing sector,” says William Schollian of American Natural BioSolvents (ANBS).

“The market demands shrinkproof, easy care wool,” says Popescu. “But the currently used Hercosett treatment to get easy care wool uses chlorine, which is environmentally harmful.” According to Brian Francois of Cognis, the use of the oxidative chlorine treatment weakens the wool fibers as well.

His company’s environmentally friendly Securlana treatment allows wool fabric to pass Woolmark’s Total Easy Care standard with only 0.5-1% shrinkage even after 40 machine wash and tumble dry cycles. “Unlike other systems
that coat the wool with polyurethane or silicone films, ours doesn’t change the aesthetics or the hand of the fabric,” Francois notes. “In addition, our treatment improves the pilling characteristics of wool fabrics.”

The USDA has also developed a more environmentally friendly process for shrinkproofing wool,” we have a domestic process for controlling the shrinkage of wool in machine washing invented by the USDA ARS Eastern Regional Research Center, whereby a novel activated peroxide system bleaches wool to a high level of whiteness at 35C for 30 minutes and is followed by enzyme treatment at 45C for 40 minutes.”

Schollion says ANBS’ environmentally friendly shrinkproofing process doesn’t contribute to wastewater issues. His company also has a bio-based dyeing auxiliary that “reduces the traditional dyeing time of wool by 50%, and gives nearly 100% exhaustion of the dye onto the wool with outstanding crocking and washfastness. Our low temperature process cuts processing time and costs and saves energy as well. It improves hand, strengthens the fibers, and improves felting resistance,” says Schollion.

According to Hannemann, Ciba has an alternative to environmentally unfriendly afterchrome dyeing. “The Lanasol CE metal-free reactive dye range has the same high fastness as the chrome dyes, but gives a softer hand and better spinnability. The old process needs two steps, but Ciba’s Lanasol CE range requires only a one step process, giving dyers higher productivity.”

Enzymes
Enzymes have been considered as a more environmentally friendly answer to both shrinkproofing and dyeing processes. According to Julie Clemmons of Novozymes, “We’re trying to improve traditional processing conditions and address environmental and safety issues by providing an enzymatic process to replace some of the chemical conditions of wool processing.”

The outer surface of wool has microscopic scales, which are the cause of wool’s felting, shrinking, and itchy properties. For shrinkproofing, enzymes called proteases can be used to blunt the edges of the wool’s scales. “As with all chemical treatments, the length of time and amount of enzyme used must be controlled,” says Clemmons. “If the enzyme is overdosed or over processed, it can attack the fiber itself and degrade strength. We are experimenting on using alcohol solvents to block the enzyme from penetrating into the fiber and keep the action localized on the surface scale to overcome strength loss issues.”

In the scouring process, lipases can be used to hydrolyze fats and oils. “This enzyme is very specific, and doesn’t damage the fiber itself,” says Clemmons.

As for enzymatic dyeing, “Under mild conditions an oxidoreductase can be used in combination with organic compounds to simultaneously form the dye and dye the wool fibers,” says Clemmons. “This enzymatic process can obtain good depth of shade and fastness properties.”

Machinery
According to Popescu, plasma technology has shown promise as an environmentally friendly and non-chemical way of shrinkproofing wool fabrics. However, it may be some time before the technology is adopted for routine production use by textile mills. Besides the high initial investment costs involved in any new technology, “the textile industry is very conservative in adopting new technology, and wool is the most traditional segment of the textile industry,” says Popescu.

THE FUTURE OF WOOL
What’s next for wool? “Plenty of things are next,” asserts Popescu. “But remember that after 25,000 years of history, it’s hard to make rapid changes.” In addition to the weight of tradition, Popescu points to the slowdown of innovation in the entire textile industry because of the costs
...we want to bring wool out of winter. ‘Cool Wool’ has been developed, and wool can be a trans-seasonal fiber—something consumers can consider wearing any season of the year.

Fiber

“The current fashion is for a very fine, soft hand and very fine micron wool,” notes Popescu. “However, if that fashion changes, you just can’t change the sheep that quickly.” Popescu feels that one of the trends of the future will be the further genetic manipulation of the sheep and of their food in order to manipulate the fiber product. “So far, selective breeding has been able to manipulate the crimp and diameter of the wool fiber,” he says. “Since 2000 it has been possible to produce shrinkproof fiber on the back of a sheep.”

According to Popescu, genetic engineering should be able to affect the wool fiber in other ways as well: specific luster, even specific color like whiter shades, or pre-colored wool with no need for dyeing (like the work being done on colored cotton).

Several experts point to the development of the Optim fiber from Woolmark, which is made from wool by stretching wool fibers and reducing their diameter and eliminating the crimp. “The wool can be reduced at least three microns in diameter,” says Popescu. He notes also that the Optim fiber has new properties that are different than wool: a silkier hand, greater luster, and a capability of more intense dyeing.

“Optim is not like traditional wool, but a fiber derived from wool, with different physical properties. This will have a big impact on the wool market because it will provide a new product for which wool is the raw material,” says De Boos. “It is of course more expensive than normal wool, but is intended for a higher value market. It is a very luxurious fiber, and is often blended with cashmere and silk.”

De Boos sees the future of wool as a luxury fiber. “It will be lighter and softer,” he says. “Additionally, we want to bring wool out of winter. ‘Cool Wool’ has been developed, and wool can be a trans-seasonal fiber—something consumers can consider wearing any season of the year.”

Processing

Popescu says that there is interest in adding value to wool at the “top” stage. “New developments in topmaking include adding chemicals to the sliver to get specific whiteness and luster during the preparation stage.”

Lewis observes that work is being done to develop environmentally safe chemistry for shrinkproofing wool at the topmaking stage as well. He also notes the need for the development of insect-resistant wool. “Mothproofing agents are essential. Moth or beetle attacks will ruin wool textiles. We have to develop chemistry to modify wool to make it indigestible to insects.”

Cardamone notes work on improving the flame resistant properties of wool with new polymer systems and with aramid blends.

Blends

The trend towards wool blends is increasing. “Wool/polyester blends will become more popular,” Lewis predicts. “As well as wool/cotton blends. There needs to be more work done on one-bath wool/cotton dyeing. We’ll need clever chemistry to fix reactive dyes on cotton under neutral pH.”

“Wool blends beautifully with synthetics and cotton, as well as the high end luxury fibers like cashmere,” agrees De Boos. Sometimes consumers want the property of the blended fiber to meet requirements that pure wool can’t meet—such as a wool/polyester suit that can be tossed in the washing machine. But often, wool blends are sought for the fiber properties that the wool brings to the mix. Wool hosts a plethora of properties in combinations that “cannot be easily imitated by synthetics,” says Hannemann. “There are things you just can’t do without wool.”

References


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