The Touch, the Feel—and Now, the Heal—of Cotton

PEGGY GREB (D1045-1)

Chemist Phyllis Howley measures blood-clotting properties on modified cotton fabrics while chemist Vince Edwards studies the resulting image analysis on a nearby computer screen.

Creating an array of valuable medical products that can halt bleeding, soothe burns, fight microbes, and more—all from farm-grown cotton.

Its cultivation may be ancient—dating as far back as 5,000 years ago—but cotton, and its characteristically soft, downy fibers, could be just what modern medicine has been waiting for.

Believed to have first been grown in the Indus Valley of current-day Pakistan and India, cotton is a favorite fiber in terms of its innate softness, breathability, and agronomic abundance. Nothing wicks moisture away better on a steamy August day. No other fabric feels as naturally smooth and airy against the skin.

And now, thanks to research done by an ARS chemist in New Orleans, Louisiana, this fabric basic is poised to help address one of our healthcare system's most costly medical conditions: debilitating chronic wounds.

An Increasing Concern

Chronic open wounds—also known as "bedsores" or "pressure ulcers"—are a painful and sometimes fatal condition afflicting about 5 million Americans. Sufferers of these hard-to-heal wounds mostly include elderly patients restricted to hospital beds or wheelchairs and diabetics beset by circulation problems.

Brought about by the constant pressure of lying on a stationary surface, painful ulcers can involve substantial skin loss, sometimes exposing muscle and even bone.

The annual healthcare costs associated with treating these wounds are currently estimated to exceed $7 billion. This figure is expected to grow by as much as 10 percent annually as the nation's population ages and the incidence of pressure ulcers increases.

And while several products are currently on the market for treating chronic wounds, there's vast opportunity for improvement, says ARS chemist Vince Edwards. "That's largely because of ongoing advances in the medical community's understanding of wound physiology," he says, "coupled with a recent growth in innovative textiles."

Edwards's research is perfect evidence of how these two worlds are merging. Weaving together a keen interest in wound medicine and an expert knowledge of cotton chemistry, Edwards has already invented a novel wound dressing that could reach hospitals and nursing homes in the next couple of years.

But that's not all. Cotton fibers in Edwards's lab, located at the agency's Southern Regional Research Center in New Orleans, are being spun into all kinds of medically promising materials. The inventive chemist and his group are creating an array of valuable medical products that can halt bleeding, soothe burns, fight microbes, and more—all from farm-grown cotton.

A Bandage With a Brain

One technology that's inching ever closer to the marketplace is a wound dressing Edwards and his group developed that targets destructive enzymes called proteases (pronounced pro-tea-ACE-es) which collect in chronic wounds.

In most chronic wounds, the problem's not that the body has a deficient immune system; it's, ironically, that the body's natural defenses are laboring in overdrive, dispatching too many "foot soldiers" to break down dead and dying tissue.

Having enough of these enzyme-producing armies, or structures called "neutrophils," is critical to healing. But too many can jam up the process, leaving it locked in a vicious, harmful inflammatory cycle.

Edwards's dressing, licensed by Tissue Technologies in Richmond, Virginia, was the first bandage of its kind with the proven ability to sop up excess protease. Tissue Technologies president Kel Cohen says the dressing, which was approved by the U.S. Food and Drug Administration in 2006, now has a manufacturer and marketer. A major goal is to introduce the product to the Veterans Administration system, where it could have significant impact.

Edwards hopes the dressing will be a cost-effective alternative to similar dressings currently available. "Especially," he says, "since we've found it's even better at sequestering protease than a comparable wound dressing currently in production."

PEGGY GREB (D1046-1)

Chemist Nicolette Prevost treats cotton fabrics with a chitosan formulation, which is designed to confer blood-clotting and antibacterial properties on wound dressings and specialty garments.

In a recent study in the *Journal of Biomedical Materials Research,* Edwards details how his bandages curtail protease activity 40 to 80 percent more effectively than untreated cotton wound dressings do.

And based on recent investigations, Edwards believes the cotton dressing may not only be suppressing overzealous enzyme-producing neutrophils, but it may also be recruiting protein-building macrophages, which are necessary for proper skin healing.

So how does an ordinary cotton bandage accomplish such healing magic? "It's simply a matter of attraction," says Edwards. He discovered that when negatively charged phosphoric acid is incorporated into cotton fibers, the dressing is able to pull positively charged proteases up and away from a wound.

Not Your Ordinary Bedsheet

As with most medical conditions, a real reduction in healthcare costs is best realized through prevention. The same applies to pressure ulcers, says Edwards. They become much more difficult to treat once they reach an advanced stage.

Specially engineered foam mattresses are one treatment alternative. Now, improved bedsheets are being designed to be compatible with that technology. When woven from the smoothest of cotton fibers, they might even prevent pressure sores from forming in the first place.

"There's a lot of potential in this field," says Edwards, "as hospital sheets haven't changed much in the last 100 years." He's exploring how to best reduce the two forces that play a major role in pressure ulcer development: friction and shear.

The slightest motion of a patient in bed creates friction between skin and sheets and results in loss of cells from the skin's outermost layer. Pressure and gravity—which might result, for instance, when a patient sits up in bed—create additional shear forces that compound cell loss.

To blunt their cumulative rub, Edwards and his group are developing super-smooth, wrinkle-free cotton sheets that can also battle microbes. And shrimp, oddly enough, can be thanked for this added benefit. The shells of these small crustaceans are composed of a unique carbohydrate, chitosan, that's a natural microbe fighter.

Since medical-based protocols don't yet exist for evaluating a bedsheet's performance, the team is relying on tests developed by the high-end garment industry to measure the sheeting material's smoothness, feel, and tendency to wrinkle.

"Eventually, we're looking at creating a multilayered sheeting system," Edwards says. "It would be made of a porous layer to address low levels of moisture, a more absorbent layer for higher levels of moisture, and a core layer for absorbing fluids such as urine." Absorbency properties in the fabric help keep the skin dry and cool, providing further protection against friction and shear.

For the War-Wounded, Too

In addition to his concerted efforts to improve treatment options for victims of pressure ulcers, Edwards has also turned his attention to patients on the battlefield.

There, the existence of a superior blood-clotting bandage can mean the difference between life and death. More than 90 percent of all combat deaths occur before the injured reach a

field hospital, many of them a result of runaway hemorrhaging, or blood loss.

While a handful of coagulant-inducing bandages are already on the market, there's always room for improved technology that boasts greater comfort and lower cost.

Turn again to chitosan, a true natural wonder. In addition to its antibacterial qualities, the shrimp-based compound is also a natural clot promoter. Dressings modified with it are currently available to members of the military, but Edwards is working to engineer them to be less brittle and more homogeneously formulated.

Cotton is ideal for dressings because it's soft, pliable, and a ready substrate for locking in health-promoting compounds. It also, as Edwards sees it, opens the door to the possibility of high-tech military clothing that could halt blood loss in a hemorrhaging event—providing protection that could prove as vital as any body armor.

Moving towards this goal, Edwards has developed an improved method for more uniformly embedding chitosan in cotton fibers. He's already turning out a variety of chitosan-laced cotton materials in his lab, including fabric for clothing, hospital sheeting, and gauze.

And by using digital imaging analysis, he and colleagues are gauging their progress, observing how well the materials perform when splattered with actual blood droplets. High-speed images are snapped, allowing the scientists to watch in slow motion as the modified cotton gauze helps red blood cells aggregate on the spot.

Like hospital bedsheets, though, any chemically amended clothing item would need to stand up to the rigors of wear and tear and multiple launderings. And, as for his hopes to develop bedsheets that can actually prevent chronic wounds, the hurdles are great too—especially given the many complex factors involved in the wounds' formation.

But Edwards isn't discouraged. He recently met with researchers at the U.S. Army Soldier Systems Center in Natick, Massachusetts, to discuss his hemostatic technologies. He stays motivated by the possibility that one day, bacteria-fighting, blood-stopping textiles made from cotton might save a life.—By **Erin Peabody,** formerly with 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.

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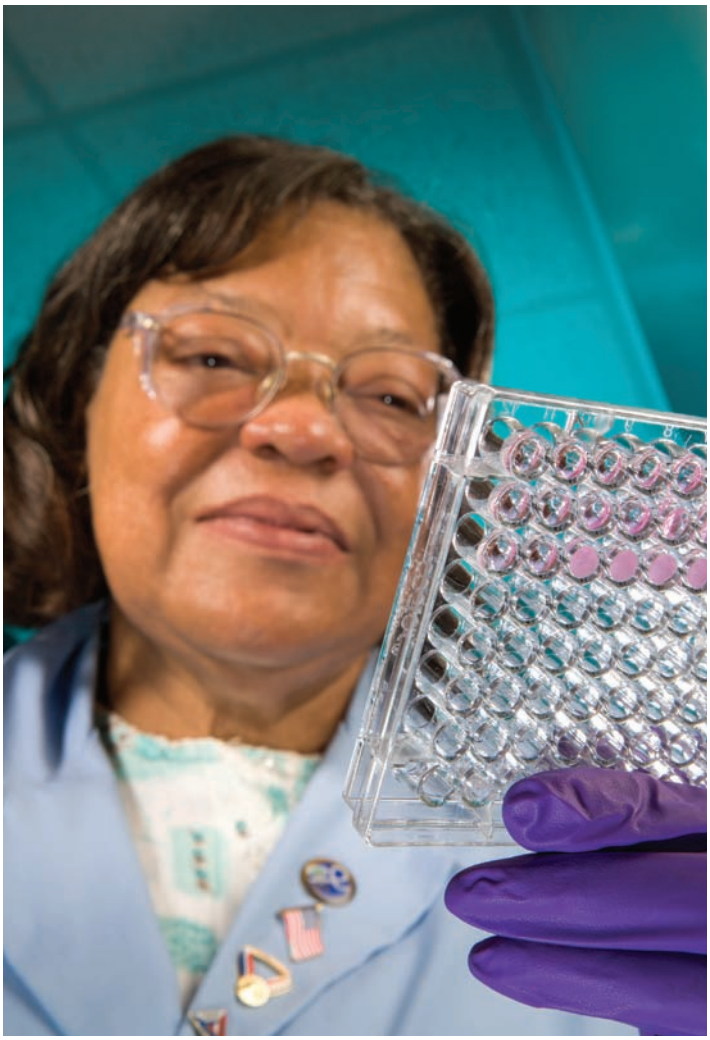
PEGGY GREB (D1047-2)



Technician Sarah Batiste observes a microtiter plate containing protease enzymes found in chronic wounds. The enzymes are trapped on specially designed cotton wound dressings being developed for patients with chronic wounds.

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