Nanotech transforms cotton fibers into modern marvel

July 8 2015, by Blaine Friedlander

Matilda Ceesay '13, left, puts the finishing touches on an anti-malarial garment worn by Sandy Mattei '14. Credit: Mark Vorreuter/File photo

Juan Hinestroza and his students live in a cotton-soft nano world, where

they create clothing that kills bacteria, conducts electricity, wards off malaria, captures harmful gas and weaves transistors into shirts and dresses.

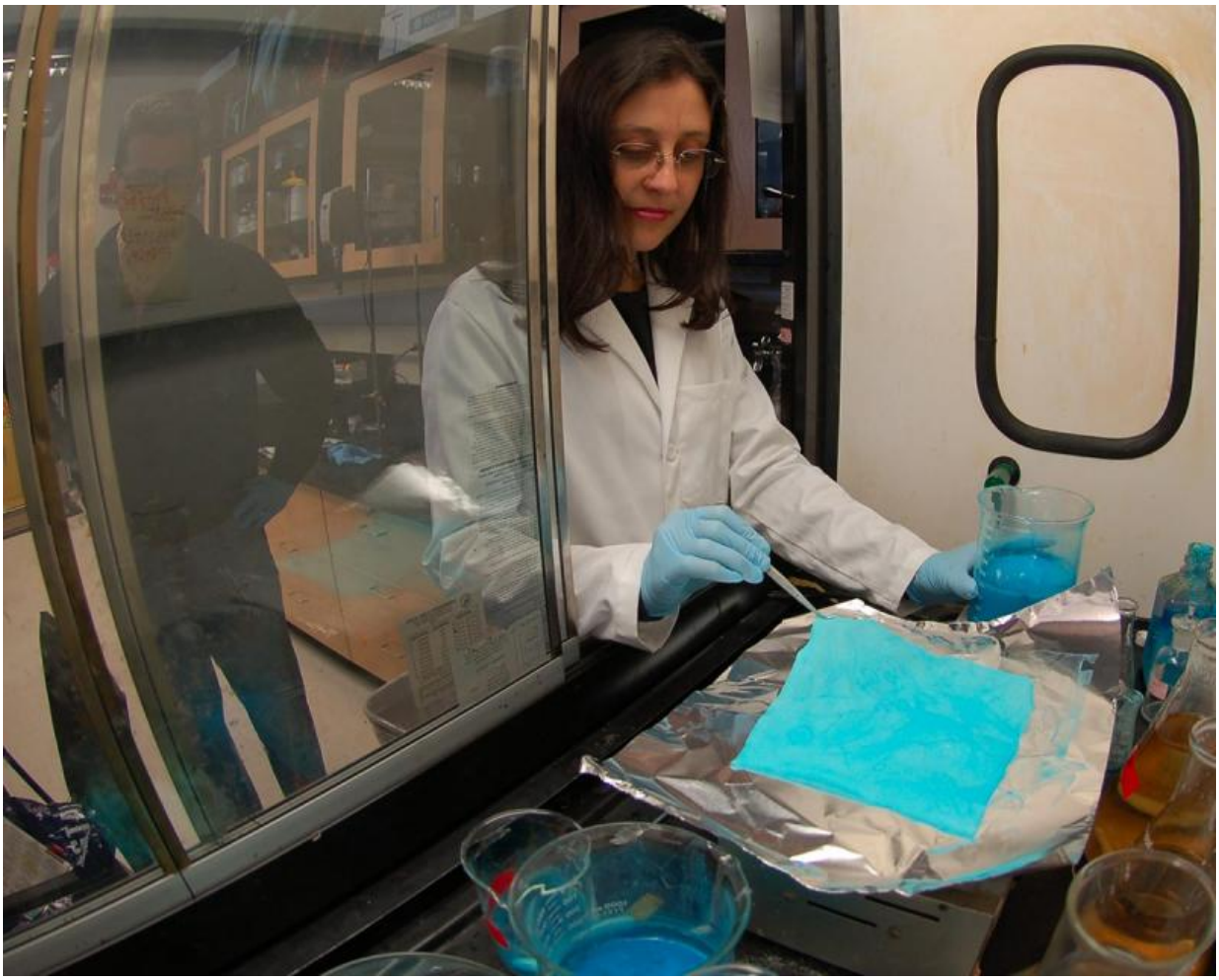
"Cotton is one of the most fascinating – and misunderstood materials," said Hinestroza, associate professor of fiber science, who directs the Textiles Nanotechnology Laboratory at Cornell. "In a nanoscale world – and that is our world – we can control cellulose-based materials one atom at a time."

The Hinestroza group has turned cotton fibers into electronic components such as transistors and thermistors, so instead of adding electronics to fabrics, he converts the fabric into an electronic component.

"Creating transistors and other components using cotton fibers brings a new perspective to the seamless integration of electronics and textiles, enabling the creation of unique wearable electronic devices," Hinestroza said.

Taking advantage of cotton's irregular topography, Hinestroza and his students added conformal coatings of gold nanoparticles, as well as semiconductive and conductive polymers to tailor the behavior of natural cotton fibers.

"The layers were so thin that the flexibility of the cotton fibers is always preserved," Hinestroza said, "Fibers are everywhere from your underwear, pajamas, toothbrushes, tires, shoes, car seats, air filtration systems and even your clothes."



Marcia Silva da Pinto, post-doctoral researcher, works on growing metal organic frameworks onto cotton samples to create a filtration system capable of capturing toxic gas, as Juan Hinestroza looks on. Credit: Mark Vorreuter/File Photo

Abbey Liebman '10 created a dress using conductive cotton threads capable of charging an iPhone. With ultrathin solar panels for trim and a USB charger tucked into the waist, the Southwest-inspired garment captured enough sunshine to charge cell phones and other handheld devices – allowing the wearer to stay plugged in.

The technology may be embedded into shirts to measure heart rate or analyze sweat, sewn into pillows to monitor brain signals or applied to interactive textiles with heating and cooling capabilities.

"Previous technologies have achieved similar functionalities, but those fibers became rigid or heavy, unlike our yarns, which are friendly to further processing, such as weaving, sewing and knitting," Hinestroza said.

Synthesizing nanoparticles and attaching them to cotton not only creates color on fiber surfaces without the use of dyes, but the new surfaces can efficiently kill 99.9 percent of bacteria, which could help in warding colds, flu and other diseases.

Two of Hinestroza's students created a hooded bodysuit embedded with insecticides – using metal organic framework molecules, or MOFs – to fend off malarial mosquitoes. Malaria kills more than 600,000 people annually in Africa. While insecticide-treated nets are common in African homes, the anti-malarial garment can be worn during the day to provide extra protection and does not dissipate like skin-based repellants.

Other students have used MOFs to create a mask and hood capable of trapping toxic gases in a selective manner. MOFs, which are clustered crystalline compounds, can be manipulated at the nano level to build nanoscale cages that are the exact same size as the gas they are trying to capture.

"We wanted to harness the power of these molecules to absorb gases and incorporate these MOFs into fibers, which allows us to make very efficient filtration systems," he explains.

Hinestroza always looks for new ways to employ cotton as a canvas for

creating infinite modern uses.

"We want to transform traditional natural fibers into true engineering materials that are multifunctional and that can be customized to any demand," he said. "We are chemists, we are material scientists, we want to create materials that will perform many functions, but have it remain flexible and as comfortable as a t-shirt or an old pair of jeans."

Provided by Cornell University