Researchers developed invisible, machine-washable solar cell technology for clothing

May 19 2022

The Sun-Powered Textiles project looked for ways to seamlessly combine solar cells and textiles. Credit: Anne Kinnunen/Aalto University

The discrete nature of the solar cells protects them—and makes the clothes more attractive, the physics and design researchers say. Promising applications include work and outdoor clothing, and curtains which react to changes in the amount of light.

In previous studies, solar cells have been installed on the surfaces, layered on top, or weaved into the threads of textiles.

During the three-year Sun-powered Textiles project, researchers at Aalto University's departments of physics and design developed a method of adhering solar cells to textiles in a way that makes them resistant to machine-washing and, at the same time, makes them less of an aesthetic problem. The researchers also took measures to make the solar cell-infused textiles recyclable.

The machine-washability of commercially available solar cells hasn't been studied previously to this extent.

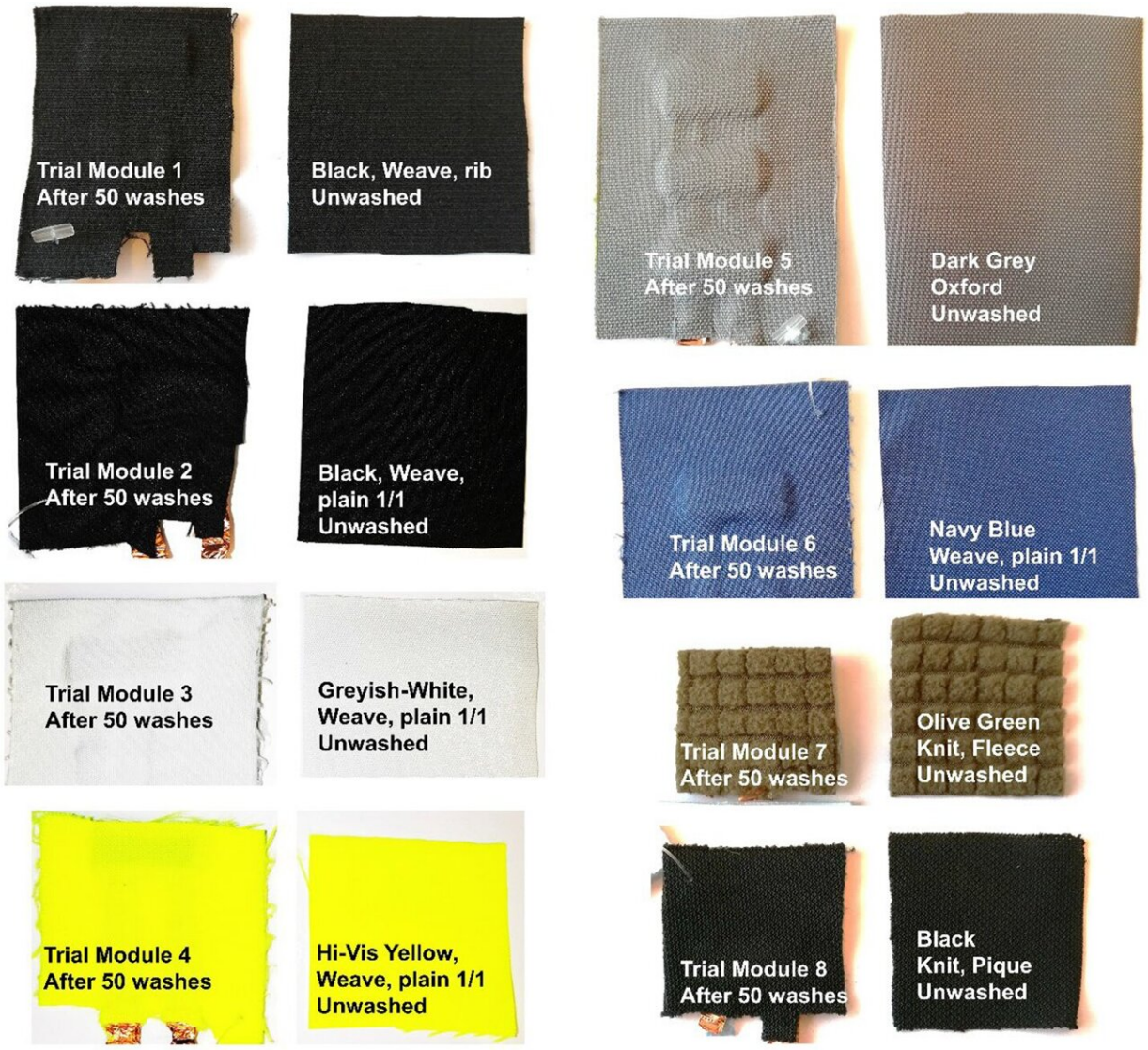
"We hypothesized that the solar cell structure might break down in the wash as the cells weren't designed to be machine-washable. The washing is a stressful process where the textiles and cells are subject to pressure and collisions, especially during spinning," says Elina Ilén, project specialist at the Aalto University Department of Design.

The researchers laminated a solar cell component between textiles in a water-tight polyurethane film to make the component machine-washable. The textiles containing the solar cell component were then washed dozens of times in 40 degrees Celsius. Physics researcher Farid Elsehrawy then measured the output of the solar cells after each round in the washing machine.

Five of the eight samples retained their efficiency, and three lost about 20 percent of their power. None of the cells or the textiles were damaged during the process.

"Now that the solar cell laminated between textiles has been proved to be machine-washable, we have to protect the rest of the components. Our idea is that all of the electric components of the smart textile could be in the same container with the solar cell. That would give us a machine-washable electronic device that's embedded in textiles and never needs to have its its battery charged or replaced," says Janne Halme, university

lecturer at the Department of Applied Physics.



Textile solar modules before (right) and after 50 cycles of washing (left). Credit: *Research Journal of Textile and Apparel* (2022). DOI: 10.1108/RJTA-01-2022-0004

Lasting power and efficient recycling

Any solar cell placed under the textile it adheres to has to have a significantly larger surface area than a cell that's placed on top. A piece of regular fabric eats up roughly 70 percent of a cell's capacity—with a more porous fabric the percentage is smaller.

Key factors in the ability of textiles to let light through them include the material, transparency and crosscut of the fiber, structure of the threads, thickness and weave of the fabric, colors and the finish. Light colors transmit light better than dark colors, but a pitch-black and completely opaque fabric can also work.

The commercial solar cells used in the study comprised of a single crystal and were made of silicon. They can detect light that is invisible to the naked eye, which is what most of sunlight actually is. Infrared is an example of such invisible light.

Hiding the textile eats up some of the solar cell's power but improves its durability, as it's better protected from the outside world.

"A cell on the surface also dominates the look of the clothing, turning it into a robot-like piece of armor. A cell on the inside makes the product much more visually palatable and affords the opportunity to visually design the product according to the user's wants and needs," Ilén says.

Researchers used materials that was made of only a single fiber and could be recycled as efficiently as possible. Electronic components can be removed from the fabric simply by first applying heat and then tearing them off.

"Previously solar cells have been weaved into the textiles as tiny pieces, which is a terrible idea in terms of recycling," Halme says.

Humidity gauges and self-adjusting curtains

The amount of energy the cells receive depends on their size, quantity and location. The amount of energy that's needed is mandated by what the use-application is. A crucial aspect is how frequently the application sends data. The most energy-hungry functions include sending information, doing calculations, and projecting on screens. That is why solar cells hidden in textiles won't be enough to charge a smartphone or a smartwatch but are suitable for things like measuring temperature and humidity.

The research team thinks that work clothing is the most potential application for solar cell textiles right now. They are thicker than regular clothes, so the cells have limited impact on the clothing's look and feel.

"Curtains are another great way to collect solar energy. They could detect the amount of light and adjust themselves accordingly," says Ilén.

The aim of the research project was to develop a technical solutions for use in many different applications. Halme advises those looking to think up more applications for the solution to consider what added value it can bring:

"Solar cells hidden under textiles are worth considering as energy sources for electrical equipment that, for one reason or another, has to adhere to textiles, look and feel like a fabric, be machine-washable, use as little power as possible, and whose battery is otherwise either too hard or too expensive to charge or replace."

The study is published in the *Research Journal of Textile and Apparel*.

More information: Elina Ilén et al, Washable textile embedded solar cells for self-powered wearables, *Research Journal of Textile and Apparel* (2022). DOI: 10.1108/RJTA-01-2022-0004

Provided by Aalto University