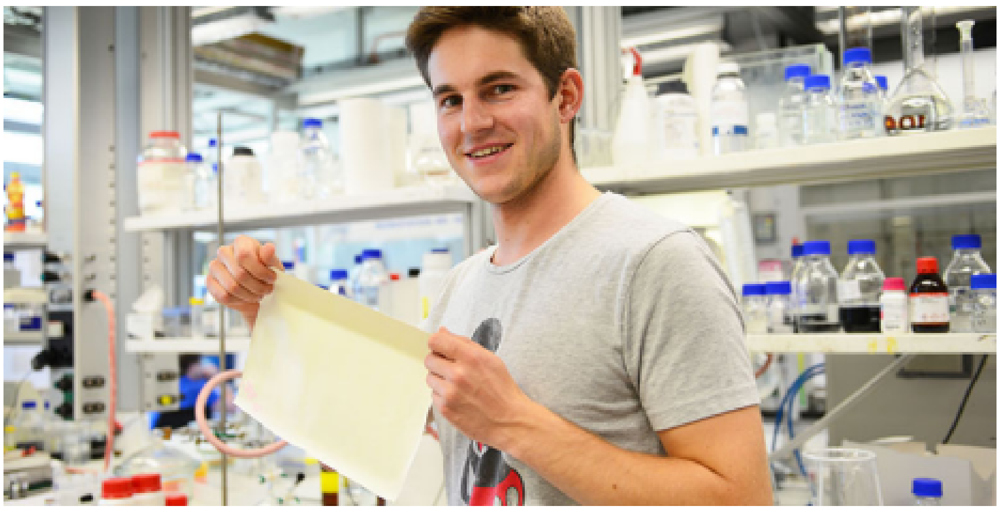
Cooling curtain made of a porous triple-layer membrane—alternative to electrically powered air conditioning

July 26 2017, by Samuel Schlaefli



Electricity savings at summer heat: Mario Stucki developed a new type of membrane that cools rooms. Credit: Peter Rüegg / ETH Zurich

Climate change is leading to ever higher temperatures and aridity in many areas, making efficient room cooling increasingly important. An ETH doctoral student at the Functional Materials Laboratory has developed an alternative to electrically powered air conditioning: a cooling curtain made of a porous triple-layer membrane.

It all began with a vague idea: "We thought it would be interesting to combine opposing functions in one material," says Mario Stucki, a doctoral student at ETH Zurich's Functional Materials Laboratory. He combined two layers of hydrophobic (water-repellent) polyurethane with a middle layer of hydrophilic (water-attracting) polymer. The resulting membrane feels dry, although it is saturated with water, and since the outer layers are covered with holes of about one micrometre in diameter, water can escape from the middle layer into the environment.

An alternative for heat-afflicted areas

When Stucki realised how well the water transport works across the various layers, he came up with the idea of the cooling curtain. "Water evaporation requires a lot of energy," he says. "Heat is extracted from the air, it cools and at the same time humidifies the surrounding area." Conventional humidifiers work in the same way – but they need a lot of power, whereas Stucki's system is passive. "The sunlight that falls through a window on to the curtain provides enough energy for this type of air conditioning."

Such curtains could be a real blessing in hot and arid regions. In 2015, people in the Arabian Peninsula endured a heatwave with temperatures of more than 50°C. Climate scientists forecast even higher temperatures and severe aridity for desert regions, which could lead to certain climate zones becoming uninhabitable. Cooling buildings and rooms is thus becoming increasingly essential, but it devours vast amounts of electricity. In the US, for example, about 15 percent of energy consumption can be attributed to air-conditioning equipment, and a huge amount of this energy comes from fossil fuels. The passive cooling curtain would be an environmentally and climate-friendly alternative.

Further development of an earlier innovation

Stucki attracted attention back in 2013 with his Master's thesis at ETH

Zurich, when he developed a new material for outdoor use in no time. In contrast to conventional functional textiles, it does not contain fluorine compounds, which are harmful to the environment and human health.

Amazingly thin: the membrane is hardly thicker than a sheet of paper. Credit: Peter Rüegg / ETH Zurich

His current research makes use of that invention: he functionalised his textile using placeholders, for which he mixed tiny lime stone particles into the liquid polymer, which is later processed into the textile. The lime stone particles are then removed from the solid material with hydrochloric or acetic acid, so that tiny holes are formed at the sites of the nano particles. These are necessary for the material to function and to "breathe". The outer walls of the cooling curtain are made of this porous material in order that the middle hydrophilic layer can deliver water to the surrounding area.

Stucki used a method developed in 2012 by ETH professor Wendelin Stark and his group to combine the different layers into one material. These layers are not glued together, as is customary in industrial processes; instead, they are placed on top of each other in a suitable solvent, whereby the outer layers dissolve slightly and connect to the middle layer. This is the only way that the researchers can ensure that the outer material of the membrane remains porous.

A successful proof of concept

Stucki was able to prove the cooling curtain's basic functionality by experiment. He put the triple-layer membrane in a water bath and measured the water loss into the surrounding area at 30°C and 50 percent humidity (between 1.2kg and 1.7kg water per day and square metre). The researchers calculated the results based on a cubic house with a 10m wall length. At an outside temperature of 40°C and an inside temperature of 30°C, the curtain surface of 80m2 was sufficient to dissipate more heat than supplied by the sunlight, meaning the house was passively cooled.

"We were able to show that our system fundamentally works," says Stucki, "but to commercialise it, we still have a lot of questions to resolve." For example, they need to determine how the material behaves microbiologically, since high temperatures and humidity form the ideal breeding ground for the growth of bacteria and fungi. Stucki says, however, that the synthetic material used for the outer layer could be replaced relatively easily with antiseptic materials; this is one of the advantages of functionalisation using lime stone nano particles.

A further challenge is to ensure that the curtain is able to evaporate water over the entire surface, which will require improvements to the water transport in the membrane. It is also still unclear how long the membrane can function stably.

After completing his doctorate in the summer, Stuck will concentrate on commercialising fluorine-free outdoor textiles. He is currently looking for financing partners. However, he has not ruled out the possibility that the new membrane also has potential in the outdoor sector, as it is ideally suited to the regulation and removal of sweat – one of the most important properties of functional textiles.

More information: Mario Stucki et al. Stabilization of 2D Water Films in Porous Triple-Layer Membranes with a Hydrophilic Core: Cooling Textiles and Passive Evaporative Room Climate Control, *Advanced Engineering Materials* (2017). DOI: 10.1002/adem.201700134

Provided by ETH Zurich