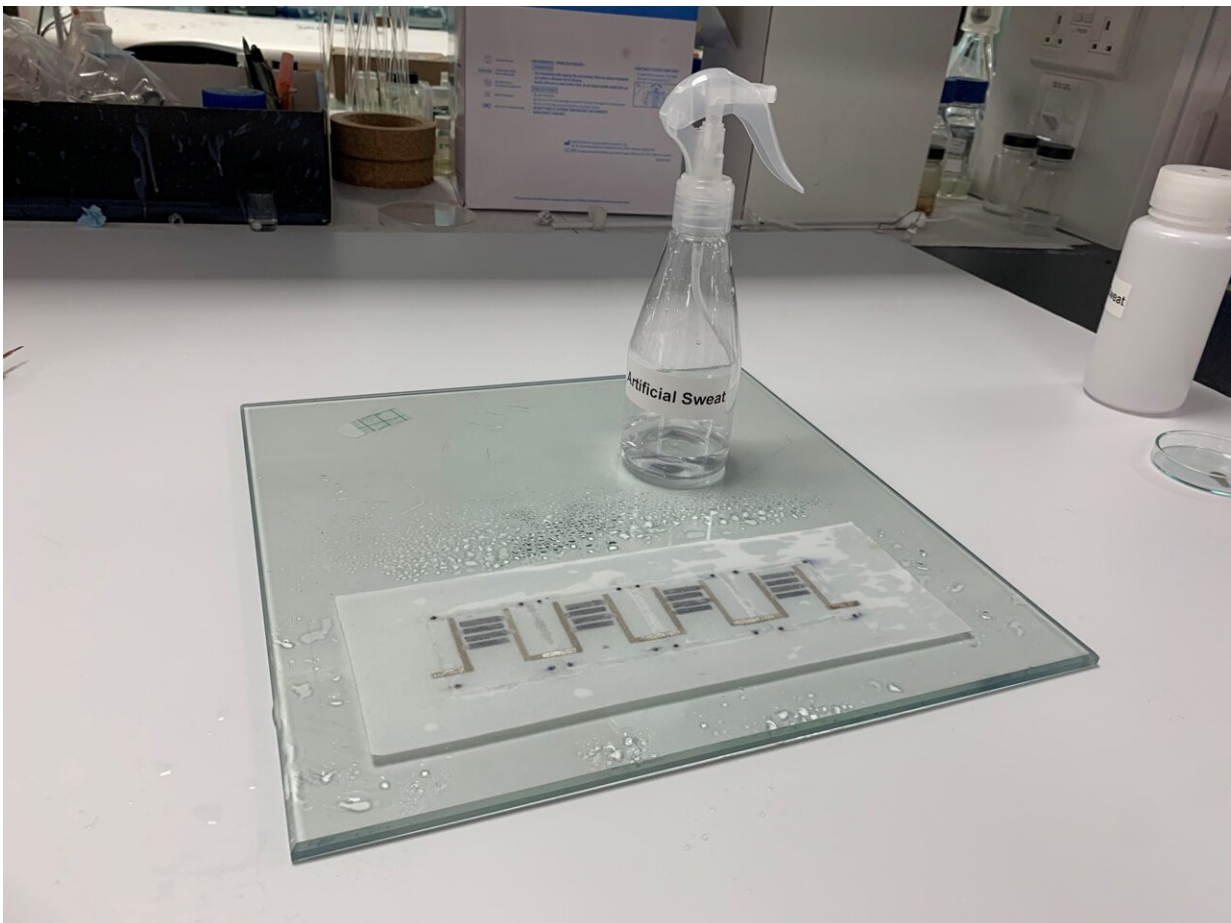


Stretchable sweat-powered battery developed for wearable tech

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To demonstrate its potential use when it becomes incorporated in wearable biosensors and other electronic devices, the team of scientists at NTU tested their device with artificial human sweat. Credit: Nanyang Technological University

Scientists from Nanyang Technological University, Singapore (NTU Singapore) have developed a soft and stretchable battery that is powered by human perspiration.

The prototype [battery](#) consists of printed silver flake electrodes that generate electricity in the presence of sweat. Measuring 2 cm by 2 cm and as flat as a small paper bandage, the battery is affixed to a flexible and sweat absorbent textile that is stretchable and attachable to wearable devices, like watches, wrist bands or arm straps.

To demonstrate its potential use when it becomes incorporated in wearable biosensors and other [electronic devices](#), the team of scientists tested their [device](#) with artificial human sweat.

In a separate trial, the team reported that an individual wearing the battery around their wrist and cycling on a stationary bicycle for 30 minutes was able to generate a voltage of 4.2 V and [output power](#) of 3.9 mW that was sufficient to power a commercial temperature sensor device and send the data continuously to a smartphone via Bluetooth.

The battery does not contain heavy metals or toxic chemicals unlike conventional batteries, which are often built using unsustainable materials that are harmful to the environment.

Serving as a more sustainable alternative that could cut down on harmful electronic waste, the development of the sweat-powered battery reflects NTU's commitment to find solutions to mitigate our impact on the environment. This is one of the four humanity's grand challenges that NTU seeks to address under the NTU 2025 strategic plan.

Materials scientist Professor Lee Pooi See, and Dean of NTU Graduate College, who led the study, said: "Our technology heralds a previously unreachable milestone in the design of wearable devices. By capitalizing

on a ubiquitous product, perspiration, we could be looking at a more environmentally friendly way of powering wearable devices that does not rely on conventional batteries. It is a near-guaranteed source of energy produced by our bodies. We expect the battery to be capable of powering all sorts of wearable devices."

The study was published in the peer-reviewed scientific journal *Science Advances* in July. A patent application for the sweat-powered battery has also been filed through NTU's enterprise and innovation company, NTUitive.

Dr. Lyu Jian, a Research Fellow from NTU's School of Materials Science and Engineering, who is the co-first author of the study, said: "Conventional batteries are cheaper and more common than ever, but they are often built using unsustainable materials which are harmful to the environment. They are also potentially harmful in wearable devices, where a broken battery could spill toxic fluids onto human skin. Our device could provide a real opportunity to do away with those toxic materials entirely."

Highlighting the significance of the work done by the NTU research team, Associate Professor Irene Goldthorpe from the Department of Electrical and Computer Engineering department of the University of Waterloo, Canada, who is not involved in the research, said: "It is well known that electronics do not like moisture and thus [wearable devices](#) are typically fully encapsulated to shield them from sweat. This work turns sweat from a hindrance into an asset, showing that it can improve the conductivity of printed interconnects and even using sweat as an electrolyte in a wearable, bendable battery. This may open a new paradigm in the design of wearable electronics."

Redefining how batteries are powered

The NTU-made battery is created by printing ink containing silver flakes and hydrophilic poly(urethane-acrylate) (HPUA), which function as the battery electrodes, onto a stretchable textile.

When the silver flakes come into contact with sweat, its chloride ions and acidity cause the flakes to clump together, increasing their ability to conduct electricity. This chemical reaction also causes an electric current to flow between the electrodes (see video).

When the battery material is stretched, its resistance is further lowered, meaning it can be used when it is exposed to strain, such as when its user is exercising.

As the stretchable textile is very absorbent, it retains a lot of sweat, so that the battery remains powered even when the rate of sweating is inconsistent. This is important for consistent functioning as the amount of human sweat secreted is variable and depends on the area of the body it is in, the environmental conditions and the time of day.

Prof Lee added: "Our device could be more durable than current technology, as we showed it could withstand strain from a wearer's daily activities, and repeated exposure to stress or sweat.

"The slim size of our battery also solves two problems in [wearable](#) tech: traditional button batteries are a problem for achieving the sort of sleek aesthetics that are attractive to consumers, while thinner batteries reduce the item's ability to carry enough charge to last throughout the day."

The researchers plan to further explore the effects of other components of human [sweat](#) and how factors such as body heat may affect the performance of the battery.

More information: Jian Lv et al, Printable elastomeric electrodes with

sweat-enhanced conductivity for wearables, *Science Advances* (2021).
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