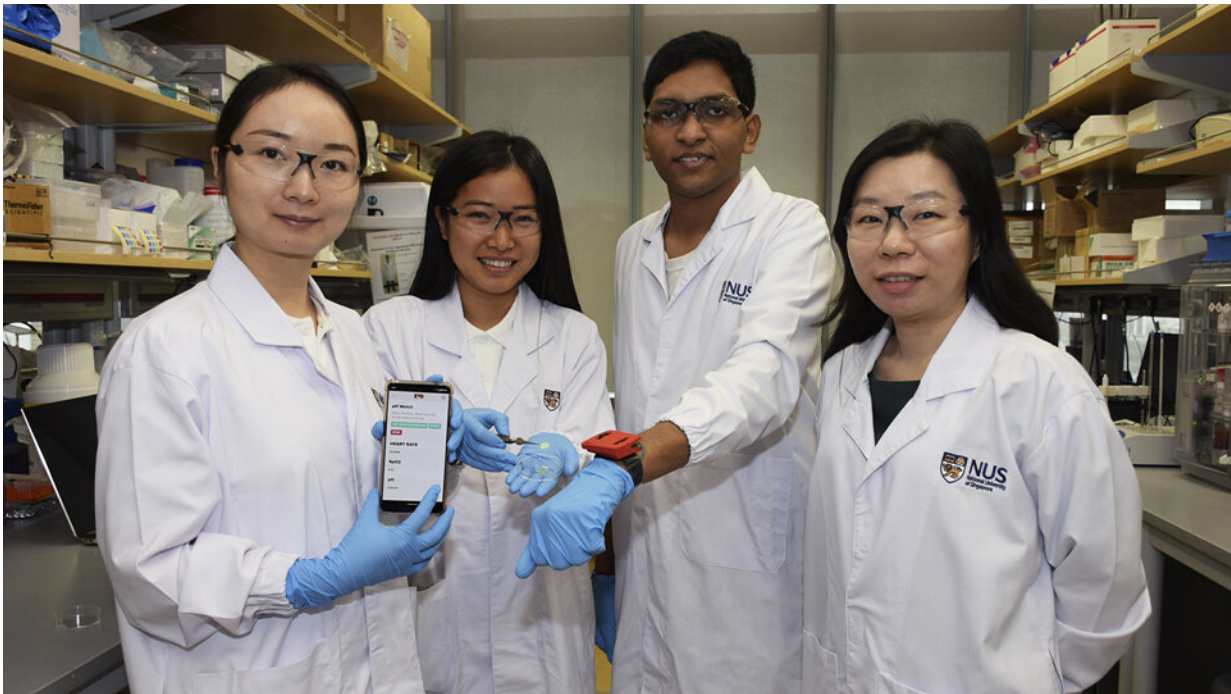


A low-power, highly responsive and reusable sweat pH monitor

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A team of NUS researchers has come up with the pH Watch, an ‘add-on’ to a wearable health monitoring gadget that can tell users about the condition of their health from their sweat pH. (From left to right) Dr Wang Bo, Ms Chen Yuan, Mr Ananta Narayanan Balaji and Assistant Professor Shao Huilin. Credit: National University of Singapore

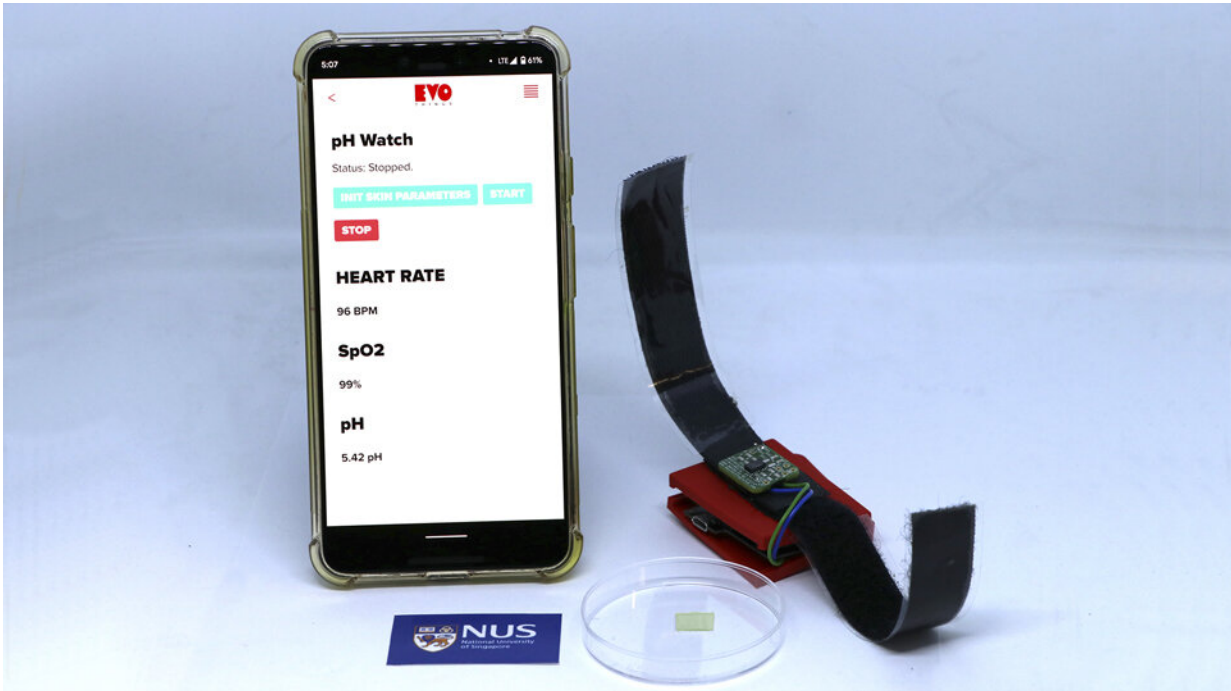
Sweat, which contains a wide range of biochemical markers, can tell us a lot about our health. Variations in sweat pH (i.e. acidity or alkalinity),

for instance, can tell us whether our body is dehydrated and can aid the diagnosis of skin conditions such as dermatitis, acne and other skin infections. In diabetic patients, sweat pH may serve as a good indicator of other life-threatening conditions, for instance, a high sweat pH during excessive sweating and night sweating may have been caused by a prolonged period of low blood glucose that warrants medical intervention.

A team of NUS researchers have come up with an 'add-on' to a wearable health monitoring gadget that can tell users about the condition of their health from their sweat. The novel sweat pH monitor, which can be easily integrated into existing fitness trackers or smartwatches at a very low cost, is able to continuously measure and monitor the acidity or alkalinity level of a user's sweat along with heart rate and oxygen concentration. In this way, users can enjoy round-the-clock, personalised, and non-invasive assessment of their well-being.

The research team comprises Mr Ananta Narayanan Balaji, a doctoral student from NUS Electrical and Computer Engineering, doctoral student Ms Chen Yuan and Assistant Professor Shao Huilin from NUS iHealthtech and NUS Biomedical Engineering, as well as Dr. Wang Bo and Professor Peh Li-Shiuan from NUS Computer Science.

"Most present day fitness trackers and smartwatches can measure health indicators such as heart rate, blood oxygen saturation levels, step count and even sleep cycle, but they are not able to track health indicators at the molecular level. Hence, we created the pH Watch because sweat is a readily accessible bodily fluid composed of a wide array of biochemical markers that can be used to monitor the well-being of individuals in a non-invasive manner," said Mr Ananta.



By integrating the NUS team's custom-made pH sensor (middle) and pH sensing algorithm into existing fitness trackers or smartwatches which already have a built-in pulse oximeter, the pH Watch can simultaneously monitor the pH value of a user's sweat, along with heart rate and blood oxygen saturation values in real-time, with about 90 per cent accuracy. Credit: National University of Singapore

Why the pH of sweat matters

The term 'pH' means 'potential of Hydrogen' and the pH scale, which measures from zero to 14, provides an indication of how acidic or basic (also called alkaline) a substance is. A pH of seven is neutral on the scale, while a pH less than seven is acidic. A reading greater than seven is alkaline. Healthy skin typically has a pH value of 5.5.

"When the body is dehydrated, there will be an increase in the concentration of sodium in sweat which is indicated by a higher pH

value. A balanced pH is also essential for skin health—if our skin is too acidic or alkaline, skin conditions such as dermatitis and acne can occur. For [diabetic patients](#), a high sweat pH during excessive sweating and night sweating may suggest that the patient is experiencing low blood glucose level," Mr Ananta explained.

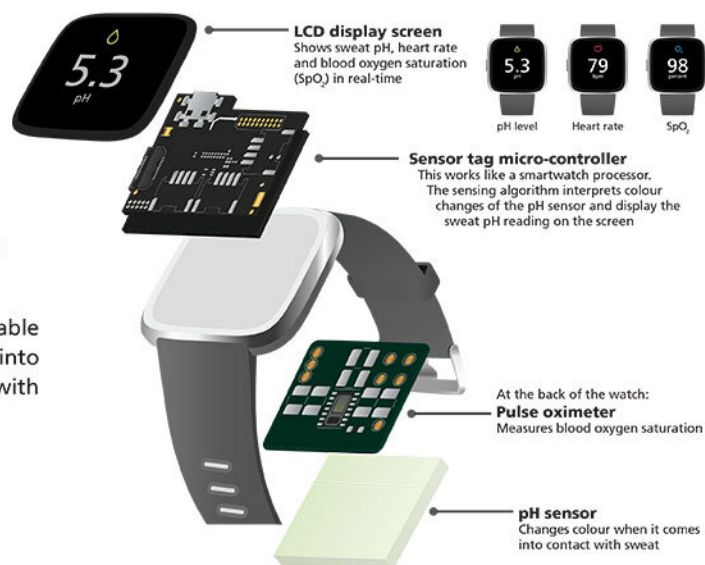
How the pH Watch works

The pH Watch invented by the NUS researchers leverages the existing pulse oximeter chips in fitness trackers and smartwatches that measure the heart rate and oxygen saturation levels of users.

Novel pH Watch invented by NUS researchers

A wearable sensor to tell whether you are dehydrated, low on sugar or at risk of skin infection from your sweat pH

The low-power, highly responsive and reusable sweat pH monitor can easily be integrated into existing smartwatches or fitness trackers with pulse oximeters at low cost.



National University of Singapore

Credit: National University of Singapore

Pulse oximeters consist of red and infrared light sensors that sit between

the skin and the device. A pulse oximeter emits visible red and invisible infrared light onto the users' skin and calculate the difference between the wavelengths of the two lights to determine the oxygen content in the blood. In hospitals, they are often clipped on the top of a patient's index finger to measure and monitor the blood oxygen saturation level of the patient.

The NUS team fabricated a flexible and highly responsive pH sweat sensor that works well with the pulse oximeter. Specifically, the sweat sensor is made using a material that changes colour when it comes into contact with different sweat pH; these colour changes are designed to match the recording capabilities of the pulse oximeter. By integrating this custom-made pH sensor and the team's pH sensing algorithm into existing fitness trackers or smartwatches which already have a built-in pulse oximeter, the pH Watch can simultaneously monitor the pH value of a user's sweat, along with heart rate and blood oxygen saturation values in real-time, with about 90 percent accuracy.

"We designed and fabricated the pH sensor from scratch using polyaniline polymer, which is an inexpensive, durable yet very flexible material. It conforms well to the skin and can be added to any smartwatch with pulse oximeter to enable continuous measurement of sweat pH. The sensor can be reused for more than a year even with daily use," said Ms Chen who developed the pH sensor.

"Our pH Watch works very efficiently. It only requires 20KB of Random Access Memory (RAM) for data processing. It is also very power-efficient—the pH sensor is passive and does not require a power source, while the pH sensing algorithm uses less than 0.01 percent of the total power consumption of a smartwatch," said Mr Ananta, who developed the pH sensing algorithm and the system prototype.

He added, "The pH sensor can be readily mounted atop any wearable

with a pulse oximeter. It can take any form—an arm band, chest strap or head band—but we have developed a watch-like wearable prototype because of the popularity of wrist-worn wearables among users. The potential use of our pH Watch is not only limited to athletes; it could be used by any user as we would sweat during daily activities like walking or running. Also, because of its non-invasive nature, it could be used as personal health monitoring device for seniors and children."

"To our best knowledge, the pH Watch is the first demonstration of a reusable sweat sensor that can be readily integrated into today's smartwatches with pulse oximeters, paving the way for ubiquitous sensing of biomarkers," said Assistant Professor Shao who supervised the project together with Professor Peh Li-Shiuan of NUS Computer Science.

The team is currently investigating other biomarkers in sweat and exploring the use of other existing sensors to detect more [sweat](#) biomarkers.

Provided by National University of Singapore

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