On-skin health monitoring electronics is next revolution in medical field to diagnose diseases to monitoring soldiers' health and stress levels in combat

Printed and Flexible electronics has started to revolutionize medical field with medical test strips with diagnostic electrodes. Engineers at the University of California San Diego have developed a flexible wearable sensor that can accurately measure a person's blood alcohol level from sweat and transmit the data wirelessly to a laptop, smartphone or other mobile device.

Fitness trackers that monitor heart rate and step count are very popular, but wearable, non-invasive biosensors would be extremely beneficial for managing diseases," said Prasad, the Cecil H. and Ida Green Professor in Systems Biology Science.

Wearable Biosensors are being developed that measure EEG, ECG, and EMG (electroencephalograms, electrocardiograms, and electromyography, tests which monitor brain, heart, and muscle activity). The next generation Wearable sensors employ lightweight, highly elastic materials attached directly onto the skin for more sensitive, precise measurements.

At the Seoul National University in Korea researchers have created a highly flexible electronic patch capable of doing basic ECG monitoring while amplifying and storing the data locally within novel nanocrystal floating gates. The patch is made of a flexible and stretchable silicon membrane on top of which gold nanoparticles are placed so as to draw the

conductive components. This eliminates conductive films that have their unique limitations while increasing the memory capacity of the device.

A soft, flexible skin patch that monitors biomarkers in sweat can determine whether the wearer is dehydrated, measure the person's blood sugar level and even detect disease. The invention is part of an emerging field of wearable diagnostics. Human sweat contains many of the same biomarkers as blood; however, analyzing sweat using a skin patch doesn't hurt like a needle stick, and the results can be obtained more quickly.

"Cosmetics companies are interested in sweat using these devices in their research labs to evaluate their antiperspirants and deodorants and so on," Rogers said. "So sweat loss and sweat chemistry is interesting in that domain, as well. And then we have contracts with the military that are interested sort of in continuous monitoring of health status of war fighters."

Skin Patch Uses Sweat to Monitor Health

The skin patch, described in the journal Science Translational Medicine, is made of flexible material, and is about the size and thickness of a U.S. quarter. The so-called microfluidic device sticks to the forearm or back like an adhesive bandage, collecting and analyzing sweat.

The first-of-its-kind patch is aimed primarily at athletes, but the flexible electronics device will in all likelihood find a place in medicine and even the cosmetics industry.

"We've been interested in the development of skin-like technologies that can mount directly on the body, to capture important information that relates to physiological health," said John Rogers, a materials scientist and bioengineer at Northwestern University in Illinois, and one of a number of

developers of the skin patch. “And what we’ve demonstrated here is a technology that allows for the precise collection, capture and chemical analysis of biomarkers in sweat and perspiration.”

The sweat is routed through microscopic tubules to four different reservoirs that measure pH and chloride, important indicators of hydration levels, lactate – which reveals exercise tolerance – and glucose. It can also track the perspiration rate.

The skin patch could potentially be used to diagnose the lung disease cystic fibrosis by analyzing the chloride content in sweat. Wireless electronics transmit the color-coded results to a smartphone app, which analyzes them.

Bioengineers create sweat-based sensor to monitor glucose

Researchers at The University of Texas at Dallas have developed a wearable device that can monitor an individual’s glucose level via perspiration on the skin. In a study recently published online in the journal Sensors and Actuators B: Chemical, Dr. Shalini Prasad, professor of bioengineering in the Erik Jonsson School of Engineering and Computer Science, and her co-authors demonstrated the capabilities of a biosensor they designed to reliably detect and quantify glucose in human sweat.

“Fitness trackers that monitor heart rate and step count are very popular, but wearable, non-invasive biosensors would be extremely beneficial for managing diseases,” said Prasad, the Cecil H. and Ida Green Professor in Systems Biology Science. But for diabetics and those at risk for diabetes, self-monitoring of blood glucose, or blood sugar, is an important part of managing their conditions.

Typical home-use blood glucose monitors require a user to obtain a small blood sample, usually through the prick of a finger and often several times a day. However, the UT Dallas textile-based sensor detects glucose in the small amount of ambient sweat on a person's skin. The team has previously demonstrated that their technology can detect cortisol in perspiration.

"In our sensor mechanism, we use the same chemistry and enzymatic reaction that are incorporated into blood glucose testing strips," Prasad said. "But in our design, we had to account for the low volume of ambient sweat that would be present in areas such as under a watch or wrist device, or under a patch that lies next to the skin."

For now, the skin patch is intended for use by sweaty athletes to measure biomarkers of performance, and Rogers sees the patch being sold with sports drinks; but, he said, a number of industries have expressed an interest in the sweat-based technology.

Nanomesh technology results in inflammation-free, on-skin health monitoring electronics

Minimal invasiveness is highly desirable when applying wearable electronics directly onto human skin. However, manufacturing such on-skin electronics on planar substrates results in limited gas permeability. The lack of breathability is deemed unsafe for long-term use: dermatological tests show the fine, stretchable materials prevent sweating and block airflow around the skin, causing irritation and inflammation, which ultimately could lead to lasting physiological and psychological effects.

According to a new study in Nature Nanotechnology, a new

approach to this technology using a nanomesh structure could have positive implications for long-term health monitoring.

The new sensors are inflammation-free, are very gas permeable, and they're thin and lightweight, without the use of any pesky substrates that can contribute to skin discomfort. That means they can be directly laminated onto human skin for longer periods of time.

The sensors' mesh structure is made of biocompatible polyvinyl alcohol, which enables that gas permeability without blocking sweat glands, and it's stretchable without causing any additional discomfort, even if it's affixed for a considerable amount of time.

A one-week skin patch test revealed that the risk of inflammation caused by on-skin sensors can be significantly suppressed by using the nanomesh sensors. Furthermore, a wireless system that can detect touch, temperature and pressure is successfully demonstrated using a nanomesh with excellent mechanical durability. In addition, electromyogram recordings were successfully taken with minimal discomfort to the user.

They're also versatile. The mesh conductors can attach to irregular skin surfaces – say, the tip of a person's finger – and maintain their functionality even when a person's natural body movements folds and elongates the skin. Nanofibres with a diameter of 300 to 500 nm were prepared by electrospinning a PVA solution, and were intertwined to form a mesh-like sheet. When the nanomesh conductors were placed on the skin and sprayed with water, the PVA nanofibers easily dissolved, and the nanomesh conductor attached to the skin.

According to the study, the approach has opened up a new possibility for the integration of electronic devices with skin for continuous, long-term health monitoring. "We learned that devices that can be worn for a week or longer for

continuous monitoring were needed for practical use in medical and sports applications," says Professor Takao Someya at the University of Tokyo's Graduate School of Engineering whose research group had previously developed an on-skin patch that measured oxygen in blood.

Furthermore, the scientists proved the device's mechanical durability through repeated bending and stretching, exceeding 10,000 times, of a conductor attached on the forefinger; they also established its reliability as an electrode for electromyogram recordings when its readings of the electrical activity of muscles were comparable to those obtained through conventional gel electrodes.

"It will become possible to monitor patients' vital signs without causing any stress or discomfort," says Someya about the future implications of the team's research. In addition to nursing care and medical applications, the new device promises to enable continuous, precise monitoring of athletes' physiological signals and bodily motion without impeding their training or performance.

Military requirements

Many militaries including those of US, China and others have expressed the desire to cut their manpower, along with stagnant growth or cuts in military budgets. On the other hands the increase in threat levels and employment of militaries in diverse and complex kind of missions has led to manifold increase in number of missions. Technological advances, such as night vision devices, have led to increase in duration of missions; militaries now operate around the clock during times of conflict. Some of the missions the soldiers perform can take weeks, away from in difficult terrain like deserts and mountains which requires maintaining an incredibly high level of physical fitness.

Krueger (1991) reported that the efficiency of combatants in sustained operations can be significantly compromised by inadequate sleep. Vigilance and attention suffer, reaction time is impaired, mood declines, and some personnel begin to experience perceptual disturbances. Naitoh and Kelly (1992) warned that poor sleep management in extended operations quickly leads to motivational decrements, impaired attention, short-term memory loss, carelessness, reduced physical endurance, degraded verbal communication skills, and impaired judgment. Angus and Heslegrave (1985) noted that cognitive abilities suffer 30 percent reductions after only 1 night without sleep, and 60 percent reductions after a second night.

Around the world, armies are recognizing the importance of maximizing the effectiveness of Soldiers physically, perceptually, and cognitively. Militaries are therefore studying effects of frustration, mental workload, stress, fear and fatigue on both cognitive and physical performance.

In November, the Office of Naval Research awarded a $150,000 grant to Titus and the tech firm Sentience Science to develop tools that could monitor an individual's stress levels in combat and automatically generate alerts when they reach dangerous levels.

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