Bio-sensing textile based patch for sweat monitoring

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It is thought that wearable sensors to monitor various health-related biometric parameters may assist in reducing the strain put on healthcare systems by ageing populations, rising costs and an increase in the incidence of chronic diseases requiring long term care. As of now, the focus has been on the use of wearable sensors to convert physical biometrics such as heart or respiration rate into electrical signals and relatively little has been done in the area of wearable chemical sensors which can be used for the real-time ambulatory monitoring of bodily fluids such as tears, sweat, urine and blood.

Exercise generates sweat naturally, and in its matrix of essential ions and molecules, sweat contains very rich information about the physiological condition of the subject. Sweat analysis is known to identify pathological disorders (such as cystic fibrosis) and has the potential to be an important diagnostic tool for other disorders. A design of a textile based fluid handling system and a pH sensor based on paired emitter-detector LEDs could be very useful in new age sweat analysis. This design, unlike others, efficiently allows sweat data to be collected during exercise. This can give valuable information on dehydration or rehydration and changes in the amount of important biomolecules and ions while the changes themselves are occurring. In the case of elite athletes and people who enjoy endurance sports, it is well known that sweat composition changes during exercise as a result of dehydration. Therefore, constant monitoring of the composition of sweat can lead to tailored rehydration strategies which improve performance and preserve the health of the athlete.

This design of the sweat collecting fluid handling platform is based on using fabrics with inherent moisture wicking properties. It collects the sweat from the skin surface and wicks the sample through a predefined channel to the sensing area. It was determined that sports materials such as polyester/lycra blends are ideal for the collection. In this arrangement, the channel of the fabric pump is connected to a reservoir of de-ionized water and the weight gain of the patch and absorbent is recorded in order to calculate the flow rate. Following this a polyurethane film is affixed to the back or skin-side of the patch, leaving a window inlet through which sweat enters the channel. An extra fluid collection layer was then attached at the back and the pH sensor is fabricated at the inlet.

A colorimetric approach is used for sweat pH measurement. This involves using a pH sensitive dye which changes color depending on the pH of the sweat. This color change is detected by diffuse reflectance measurement using an emitter-detector LED technique. During exercise, human sweat typically varies from pH 5–7. The detector LED is reverse biased at a specific voltage and the photocurrent generated upon incident light then discharges the LED at a rate that is proportional to the intensity of light reaching the detector. The optical detector is controlled using a CrossbowMica2dotmote. A simple threshold detection/timer routine is implemented and data is transmitted wirelessly to aMica2 base station connected to a laptop for analysis. The LEDs are positioned over the fabric channel fixed inside a black PMMA cover fitted into the rubber gasket.

For on-body trials, a waistband that houses the pH sensor, electronics and a reference patch, is used. The pH sensor is enclosed by the waistband so that only the collection layer was in contact with the skin. In testing the device, it was observed that 5–10 min must be allowed for the acquisition layer to become saturated for sufficient sweat to enter the channel of the fluid handling system. In general the priming process takes from 25 to 30min. The fluid handing system is able to collect sweat from the skin and transport it in a controlled way down the channel and into the absorbent. Also, by placing sensors along the channel, a biochemical analysis of that sweat can be obtained. The pH sensor developed has shown an increase in sweat pH during exercise which demonstrates the relationship between pH and sweat rate.

Future work will focus on the integration of the pH sensor with sodium and conductivity sensors and the use of a Bluetooth communication system for sensor control.

References:

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