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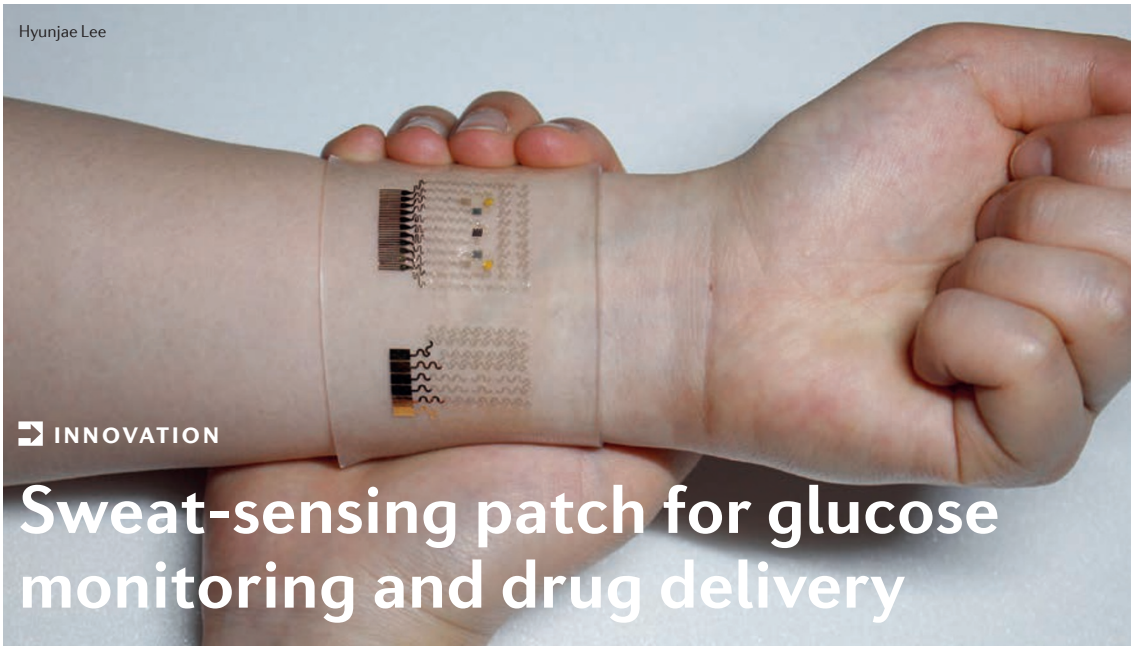
Hyunjae Lee

INNOVATION

Sweat-sensing patch for glucose monitoring and drug delivery

In a new study published in *Nature Nanotechnology*, Hyunjae Lee and colleagues report the development of a wearable, minimally invasive electrochemical device that couples real-time monitoring of glucose levels in sweat with controlled delivery of antidiabetic drugs through the skin. This technological advance brings one step closer point-of-care treatment for patients with diabetes mellitus.

The investigators, led by Dae-Hyeong Kim, used a gold–graphene hybrid material to fabricate a skin-mounted device that incorporates modules for sweat collection, an enzyme-based glucose sensor (glucose oxidase) and a thermoresponsive microneedle drug delivery system. The device is powered by a portable electrochemical analyser that wirelessly transfers collected data to mobile devices such as smartphones and tablets. Additional sensors in the device enable real-time correction of sweat glucose measurements to take account of changes in pH and temperature. Accuracy of glucose sensing is maintained by a humidity sensor, which activates the other sensors when the relative humidity in the patch exceeds 80% (the threshold value for accurate glucose sensing). Upon reaching a predetermined glucose threshold (for example, one emulating hyperglycaemia), thermal activation of the drug-loaded microneedles is triggered.

> “This technological advance brings one step closer point-of-care treatment for patients with diabetes mellitus”

Sensitivity of the glucose sensor was tested in two healthy volunteers (men aged >20 years) who had no history of diabetes mellitus. Levels of glucose in sweat were measured over a 24-h period using the fabricated patch and a commercial glucose assay kit, and compared with blood glucose levels determined using a commercial glucose meter. The patch detected elevated glucose levels after meals (breakfast, lunch and dinner) and their subsequent decline due to normal insulin secretion. Furthermore, statistical analysis confirmed a reliable correlation between sweat glucose measurements obtained with the patch and the glucose assay, as well as with the blood glucose readings ($P<0.001$ in both cases). Therapeutic efficacy of the device was tested in 8–10-week-old genetically diabetic (*db*/*db*) mice by laminating the patch (microneedles preloaded with the glucose-lowering drug, metformin) onto the skin of the abdomen. Mice receiving metformin transcutaneously had significantly lower blood glucose levels than control mice (patch without metformin or no patch; all $P<0.05$).

“For a long time, pain-free glucose monitoring and drug delivery (without blood collection and the need for injections) has been an idealized, yet elusive, goal,” explains Kim. “Our study highlights the tremendous potential of sweat-based sensing of glucose and microneedle-mediated drug delivery for the management of diabetes mellitus.” The investigators are currently working on improving the sensitivity, reliability and reusability of their device, with a view to commercializing the technology.

In an accompanying commentary, Richard Guy of the University of Bath, UK, who was not involved in the study says “although the holy grail of diabetes management — a noninvasive feedback system combining glucose monitoring and responsive drug delivery — is not yet at hand, Kim and co-workers have certainly moved the field closer to this coveted prize.” As the technology has the potential to reduce the poor adherence to glucose monitoring prevalent in the diabetic population, future developments are eagerly awaited.

David Holmes

ORIGINAL ARTICLE Lee, H. *et al.* A graphene-based electrochemical device with thermoresponsive microneedles for diabetes monitoring and therapy. *Nat. Nanotechnol.* http://dx.doi.org/10.1038/nnano.2016.38 (2016)
FURTHER READING Guy, R. Diagnostic devices: Managing diabetes through the skin. *Nat. Nanotechnol.* http://dx.doi.org/10.1038/nnano.2016.53 (2016)