Super-sensory band-aid for people in pain

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A new prototype of an electronic skin patch can detect muscle tremors and deliver drugs from nano-particles, writes David Talbot.

Offering a preview of what future wearable medical devices may look like, researchers in Korea have built a skin patch that's thinner than a sheet of paper and can detect subtle tremors, release drugs stored inside nano-particles on-demand, and record all of this activity for review later.

While still under development, the technology might someday be useful to sufferers of Parkinson's disease or other movement disorders.

"The system represents a new direction in personalised health care that will eventually enable advanced diagnostics and therapy on devices that can be worn like a child's temporary tattoo," says Dae-Hyeong Kim, assistant professor of chemical and biological engineering at Seoul National University, who led the work.

Work in progress

The work was done with researchers at MC10, a startup in Cambridge, Massachusetts, that is working on commercialising the underlying "stretchable electronics."

MC10, which has investments from big medical device companies including Medtronic, is working with partners in the pharmaceutical and medical device industries to launch products that would do part of what the Korean group demonstrated: detect and store signals like tremors, respiration, heart rate, and temperature so that doctors can review data about neuromuscular and cardiovascular disorders.

"Existing classes of electronics are rigid and packaged, leading to bulky strap-on monitors; the new technology would be unobtrusive and practically unnoticed by the wearer, says Roozbeh Ghaffari, co-founder of MC10.

A paper released on Sunday in Nature Nanotechnology describes multiple nano-scale membranes packaged as a system for motion sensing, drug delivery, and data storage — all of it integrated on a stretchable patch, like a band-aid, that would adhere on the skin.

Drug therapy tests on human patients are still a few years off; so far, the group has demonstrated how it can release a dye on a patch of pig skin.

Nanomembranes in use

Spring-like strain gauges measure muscle activity. These consist of silicon nanomembrane sensors in a serpentine shape, each curve several hundred micrometers apart.

When stretched, changes in electrical resistance on the filaments are detected, and the frequency of the signals indicates whether a stretch was from a normal arm movement or a fast tremor.

The data is recorded on a simple memory system, consisting of memory cells just 30 nm thick; these cells record high resistance versus low resistance states due to changing electrical properties across the membranes.

In the future, these data could be accessed through an RFID tag integrated into the device, or might be streamed to a nearby smartphone; however, the communications component has not yet been added.

Heat matters

The patch also contains heating elements that can be activated remotely to release drugs. The heating elements raise the patch temperature several degrees, which in turn releases drugs surrounded by porous silica nano-particles.

When heated, the physical bond between the drug and nano-particles breaks, leading to a diffusion-driven release of molecules through the skin.

“Ultimately we will develop a fully automated system that incorporates these sensors and a memory and drug-release mechanism together with a microcontroller to deliver automated drug release in an epidermal patch,” Ghaffari says.

While the prototype is focused on detecting movement disorders, other versions could sense things like perspiration, temperature, heart rate, or blood oxygen, and use those changes as a triggering mechanism for various therapies.

The teams are working to bring this platform through regulatory and clinical studies.
The work builds on the fundamental research of John Rogers, a materials scientist at the University of Illinois. Three years ago, he introduced the idea of “epidermal electronics,” or ultrathin, skin-like semiconductor materials that could monitor vital signs on the skin.

“What this paper does is take the epidermal electronics and couple it with memory onboard, and therapy. You can close the loop from diagnosis to therapy on a single patch," Ghaffari says.

Other researchers have demonstrated competing approaches. For example, a beneath-the-skin drug-release chip is being developed commercially by MicroChips of Lexington, Massachusetts. That company was co-founded by Robert Langer, a biomedical engineer at MIT.