Smart skin is powered by the objects it touches

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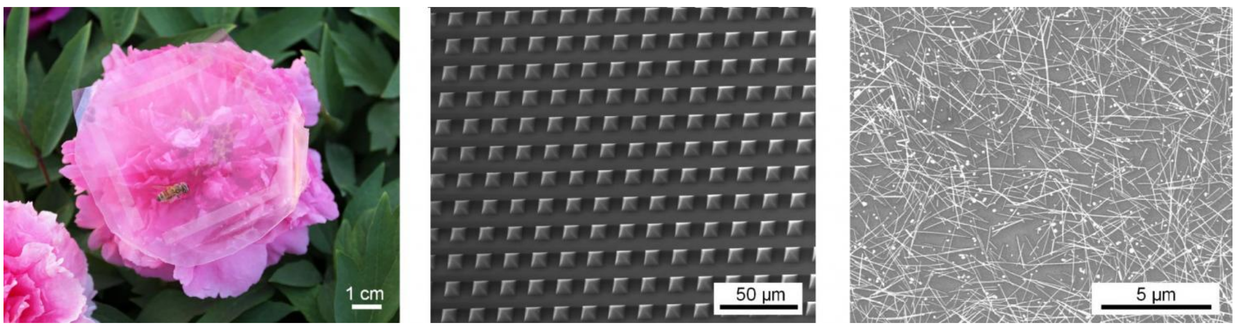

(Left) The highly transparent smart skin on top of a flower. (Center) Microstructures and (right) nanowire electrodes of the smart skin. Credit: Shi, et al. ©2016 American Chemical Society

(Phys.org)—Researchers have fabricated a smart skin that is self-powered by its frictional contact with the objects that it touches. When a honeybee crawls across the smart skin, the skin not only senses the insect, it also uses the spontaneous triboelectric charge that builds up between the honeybee and the smart skin to power its sensing ability, eliminating the need for batteries. The smart skin could have applications for robots, artificial intelligence systems, and bionic limbs for amputees.

The researchers, led by Haixia Zhang at Peking University in Beijing, have published a paper on the new smart skin in a recent issue of *ACS*

Nano.

"For conventional electronic skins or smart skins, they all need a power supply," Zhang told *Phys.org*. "This is a serious problem. It's awkward for users to take a thin, flexible and light-weight smart skin together with a hard and heavy battery that can work only for hours. The self-powered smart skin fundamentally solves this problem."

As the scientists explain, triboelectric charges occur anywhere two objects touch each other, although these charges are so small that they often go overlooked.

"Imagine a scenario where you walk toward a table to get a cup of coffee," Zhang said. "Opposite charges will be generated on the surface of your shoes and the ground. Then when you pick up the cup to drink, the opposite charges will be generated on the palm of your hand and the handle of the cup. Furthermore, when you swallow the coffee, the charges will even be generated between the surface of your digestive tract and the coffee. We utilized these spontaneous—but often be ignored—charges to make our smart skin totally self-powered."

This self-powering method is possible because the smart skin consumes very little energy in the first place. Most other previously developed smart skins are digital, meaning their resolution sensitivity is determined by a grid of pixels. Increasing the resolution usually requires increasing the number of pixels and electrodes.

In contrast, the new smart skin uses an analogue method that requires only four electrodes. The electrodes are positioned at four opposite ends of the smart skin. When an object, such as a finger, applies a pressure to the smart skin, it generates a current through the skin that induces a voltage on each electrode. Since the distance between the applied force and each electrode is different, the voltage at each electrode will also be different, and the relative voltages can be used to pinpoint the location of the applied force.

"We use the spontaneous triboelectric charges, combined with planar electrostatic induction, to sense the touch applied on the smart skin," Zhang said. "The triboelectric charges occur everywhere in our daily life when two surfaces touch each other. And when a charged surface approaches a metal block (or electrode), it will induce the opposite charges, which is the electrostatic induction effect. The intensity of the electrostatic induction effect depends on the distance between the charged surface and metal."

The researchers' experiments showed that, when wrapped around a robotic hand, the analogue smart skin can determine the location of an applied force with an average resolution of 1.9 mm. To demonstrate the high sensitivity of the smart skin to very small forces, the researchers showed that the smart skin can detect the presence of a 0.16-gram honey bee, as well as a jumping cricket.

In the future, the researchers hope to further improve the smart skin by increasing its detection resolution and sensitivity, which can be addressed at a low cost since these improvements do not require additional electrodes. The researchers also plan to develop ways to shield the smart skin from interference from the environment and other electronic components, which poses a problem for when the smart skin is integrated into mobile phones.

"Compared with digital smart skins which have been studied extensively, analogue smart skins still need more in-depth study," Zhang said. "Analogue smart skins have obvious advantages at resolution and energy consumption. I hope our work can draw more attention to the analogue smart skins."

More information: Mayue Shi, et al. "Self-Powered Analogue Smart Skin." *ACS Nano*. DOI: 10.1021/acsnano.5b07074