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Wear and forget: An ultrasoft material for on-skin health devices

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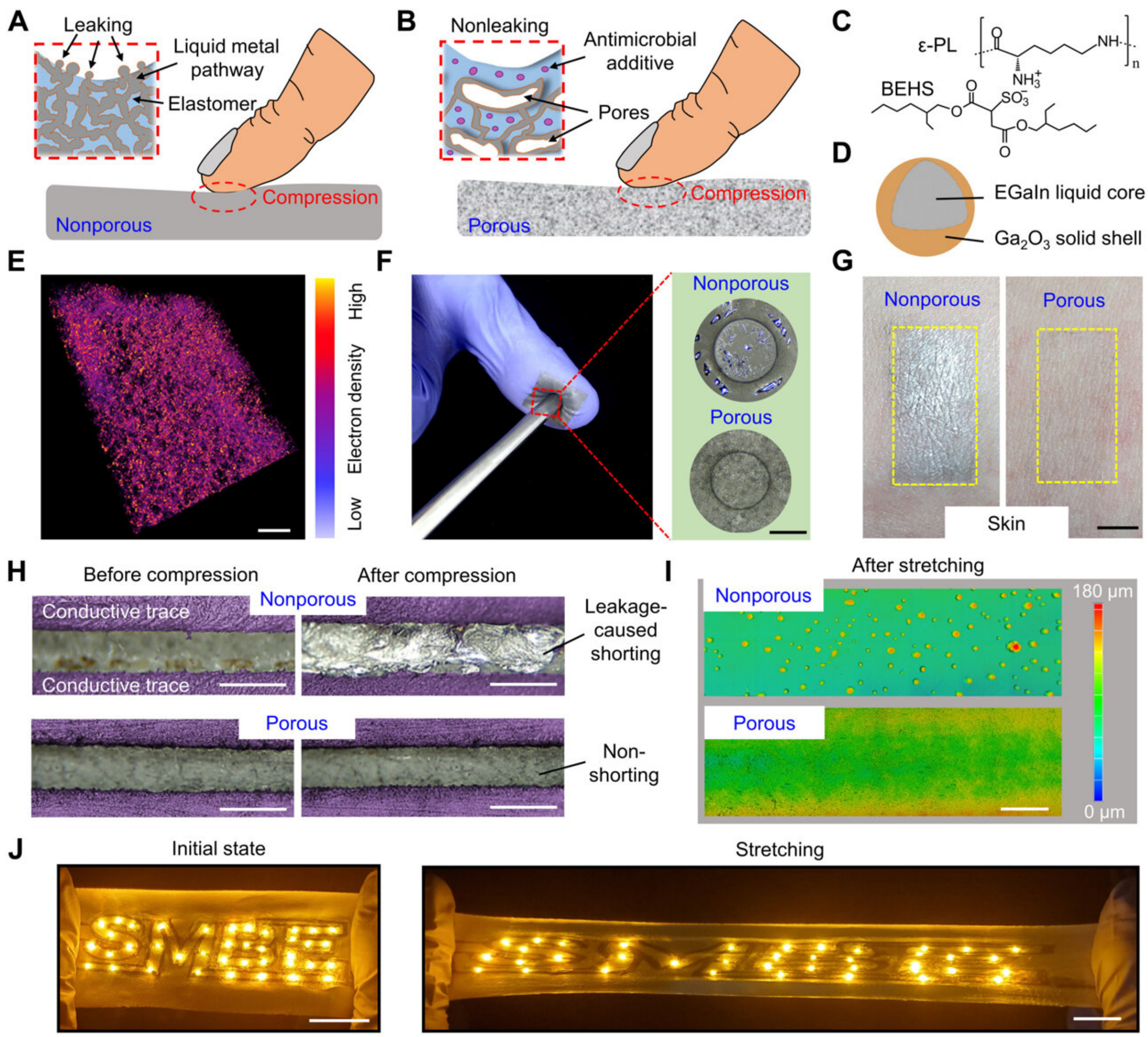

Leakage-resistant property. Conceptual illustration of conventional nonporous (A) and multifunctional porous (B) EGaIn composites upon compression. Here, porous structures can provide damping effect to substantially reduce stresses induced on liquid metal conductive pathways, therefore endowing leakage-resistant property. In addition, antimicrobial additive can offer antibacterial and antiviral property. (C) Chemical structure of the antimicrobial additive, ε-PL, modified with BEHS for uniform dispersion in solvents. (D) Schematic of the EGaIn particle made by tip sonication of bulk EGaIn. (E) 3D tomography image of porous composites before sintering, showing EGaIn particle (yellow) distributions in elastomers (pink). Scale bar, 100 μm. (F) Photographs of compressing EGaIn composites with a stainless steel rod, demonstrating evident leakage on nonporous composites and indiscernible leakage on porous composites. Scale bar, 500 μm. (G) Photographs of human skin after wearing nonporous and porous EGaIn composites for 3 days, showing notable smearing effects induced by nonporous EGaIn composites. Scale bar, 5 mm. (H) Photographs of two adjacent conductive traces made of nonporous (top) and porous (bottom) EGaIn composites before and after repetitive compression (0.4 MPa, 100 cycles). Scale bars, 500 μm. (I) 3D surface tomography images of porous and nonporous EGaIn composites after cyclic stretching (400%, 100 cycles). Scale bar, 1 mm. (J) Photographs of light-emitting diode arrays, interconnected with conductive traces of porous EGaIn composites, at the initial (left) and 200% stretching (right) states. Scale bars, 2 cm. Credit: *Science Advances* (2023). DOI: 10.1126/sciadv.adf0575

With cancer, diabetes and heart disease among the leading causes of disability and death in the United States, imagine a long-term, in-home monitoring solution that could detect these chronic diseases early and lead to timely interventions.

Zheng Yan and a team of researchers at the University of Missouri may have a solution. They have created an ultrasoft "skin-like" material—that's both breathable and stretchable—for use in the development of an on-skin, wearable bioelectronic device capable of simultaneously tracking multiple vital signs such as blood pressure, electrical heart activity and skin hydration.

"Our overall goal is to help improve the long-term biocompatibility and the long-lasting accuracy of wearable bioelectronics through the innovation of this fundamental porous material which has many novel properties," said Yan, an assistant professor in the Department of Chemical and Biomedical Engineering and the Department of Mechanical and Aerospace Engineering.

Made from a liquid-metal elastomer composite, the material's key feature is its skin-like soft properties.

"It is ultrasoft and ultra-stretchable, so when the device is worn on the human body, it will be mechanically imperceptible to the user," Yan said. "You cannot feel it, and you will likely forget about it. This is because people can feel about 20 kilopascals or more of pressure when something is stretched on their skin, and this material creates less pressure than that."

Its integrated antibacterial and antiviral properties can also help prevent harmful pathogens from forming on the surface of the skin underneath the device during extended use.

"We call it a mechanical and electrical decoupling, so when the material is stretched, there is only a small change in the electrical performance during human motion, and the device can still record high-quality biological signals from the human body," Yan said.

While other researchers have worked on similar designs for liquid-metal elastomer composites, Yan said the MU team has a novel approach because the breathable "porous" material they developed can prevent the liquid metal from leaking out when the material is stretched as the human body moves.

The work builds on the team's existing proof of concept, as demonstrated by their previous work including a heart monitor currently under development. In the future, Yan hopes the biological data gathered by the device could be wirelessly transmitted to smartphone or similar electronics for future sharing with medical professionals.

"Porous liquid metal–elastomer composites with high leakage resistance and antimicrobial property for skin-interfaced bioelectronics" was published in *Science Advances*.

More information: Yadong Xu et al, Porous liquid metal–elastomer composites with high leakage resistance and antimicrobial property for skin-interfaced bioelectronics, *Science Advances* (2023). DOI: 10.1126/sciadv.adf0575

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