Ultra-soft and highly stretchable hydrogel-based sensor for monitoring overactive bladder

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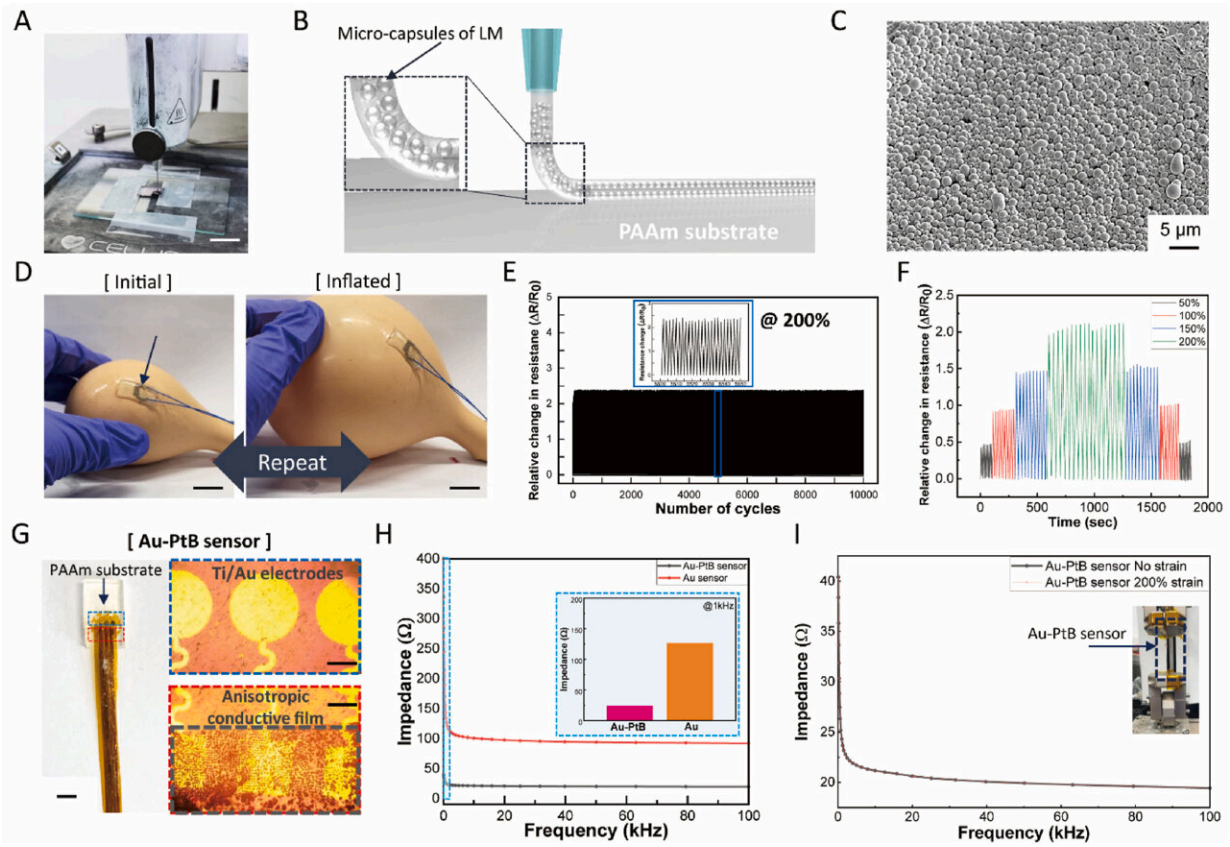

(A) The photograph of meniscus-guided coating of EGaIn* (EGaIn liquid metal particle) on a PAAm substrate. Scale bar, 10 mm; (B) Schematic illustration of printed EGaIn* on PAAm substrate; (C) SEM images of printed EGaIn* on PAAm substrate; (D) Photograph of mimicking micturition using artificial bladder. Scale bar, 5 mm; (E) The plot of relative resistance change of the strain sensor under repeated 10,000 cycles at 200% strain; (F) Plot of relative

resistance change under various strains; (G) The photograph (Scale bar, 5 mm) and optical microscopy images of the EMG sensor and anisotropic conductive film integrated on top (Scale bar, 100 μm); (H) Plot of impedance versus frequency of Au EMG sensor with and without Platinum black coating; (I) Plot of impedance versus frequency of EMG sensor before and after 200% strain. Credit: *Biosensors and Bioelectronics* (2023). DOI: 10.1016/j.bios.2023.115060

Modern living seems to have exacerbated the conditions of our gut. There is an escalating prevalence of irritable bowel syndrome and overactive bladder syndrome among individuals who do not exhibit signs of infectious maladies or other established ailments, but rather report experiencing sudden symptoms. Recently, a team of researchers from POSTECH and Korea Advanced Institute of Science and Technology (KAIST) have proposed a sensor to monitor overactive bladders.

The research team consisting of Professor Sung-Min Park and Young-Soo Lim at POSTECH's Department of Convergence IT Engineering and Professor Steve Park and Byungkook Oh at KAIST's Department of Materials Science has developed an ultra-soft and highly stretchable tissue-adhesive hydrogel-based multifunctional implantable sensor for monitoring overactive bladders. The research findings were published in *Biosensors and Bioelectronics*.

Overactive bladder syndrome is a medical condition characterized by an uncontrollable, frequent urge to urinate. People with the syndrome may even wake up during the night to urinate, without any underlying illness. The condition is not life-threatening, but it can disrupt the patients' daily activities, reducing their quality of life.

People with overactive bladder syndrome have traditionally relied on medication for treatment, which has proven to be ineffective for some.

A relatively new treatment involves giving electrical stimulation directly or indirectly to nerves linked to the bladder in order to reduce excessive bladder activity. However, this treatment is not without its challenges, as it can be difficult to deliver the right amount of stimulation to the nerves without monitoring bladder activities. Overstimulation can lead to side effects or render the treatment ineffective.

Hence, the researchers focused on developing a monitoring device to observe bladder activity in real-time. Since detrusor muscle is controlled by neural activity, they hypothesized that a full electromechanical measurement was required to accurately monitor overactive bladder symptoms. From that perspective, the team designed a USH-SI sensor that can monitor both mechanical (strain sensor to measure contraction and relaxation) and bioelectrical (EMG sensor to measure neural signal) activities of the bladder in one platform.

In a test where the team surgically inserted the USH-SI sensor into an anesthetized pig, it was demonstrated that the sensor is capable of measuring in-vivo strain and EMG signals of the bladder, allowing monitoring of detrusor muscle locomotion and neural activity. In particular, the strong adhesiveness of the hydrogel (adhesive strength: 260.86 N/m) enabled firmer attachment onto the bladder compared to conventional silicone sensors. Sensor insertion can be performed using surgical-robot-assisted laparoscopic surgery.

"The new sensor shows that sensors can be made small enough to be inserted by surgical-robot-assisted laparoscopic surgery," explained Professor Steve Park from KAIST. He added, "This has the potential to minimize the time taken for a patient to recover and reduce side effects."

"We combined the USH-SI sensor with a neural stimulator targeted to treat overactive bladders, a chronic condition," remarked Professor Sung-

Min Park who led the study. He further explained, "This allows for monitoring and neural stimulation simultaneously. We expect it to be a platform that can be applied to other internal organs."

More information: Byungkook Oh et al, Ultra-soft and highly stretchable tissue-adhesive hydrogel based multifunctional implantable sensor for monitoring of overactive bladder, *Biosensors and Bioelectronics* (2023). DOI: 10.1016/j.bios.2023.115060

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