



KOREA INSTITUTE OF
MACHINERY & MATERIALS

Press Release

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KIMM develops a flexible, stretchable battery capable of moving smoothly like snake scales

- Stretchable battery technology mimicking snake scales has been developed by the research team at the KIMM Department of Nano-Mechanics -
 - The research results have been published online in the prestigious journal *Soft Robotics* -
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The Korea Institute of Machinery and Materials (KIMM, President Sang Jin Park), an institute under the jurisdiction of the Ministry of Science and ICT, has developed a flexible, stretchable battery that bends and stretches like a snake. This new battery is expected to have a wide range of uses, such as in energy storage technology and disaster situations, by applying it to various types of devices, from soft robots to wearable devices.

The KIMM research team, led by Senior Researcher Dr. Bongkyun Jang and Principal Researcher Seungmin Hyun at the Department of Nano-Mechanics, developed a stretchable battery structure whose safety and stretchability are based on the structure of snake scales. On August 16th, the team's findings were published online in *Soft Robotics*, a prestigious journal in the field of soft robotics.

* Title: Bioinspired, Shape-Morphing Scale Battery for Untethered Soft Robots

As was described with the boa constrictor that swallowed the elephant in the novella *The Little Prince*, a snake's individual scales, while rigid, can fold together to protect against external impact. They also possess structural characteristics that allow them to be highly stretchable and move flexibly.

The KIMM research team developed the highly stretchable battery with an excellent stability and performance by fabricating the mechanical meta structure mimicking a snake's scale. Unlike conventional wearable devices, in which the device's frame and the battery are combined in a tight formation, this new technology enables flexible movement by connecting several small, hard batteries in a scale-like structure.

To ensure the battery's safety, the research team also minimizes deformation of the materials composing battery by optimal design of the scale-like structure. Also, the shape of each battery cell was optimized to achieve high capacity per a unit size.

Designing the shape of the battery cell and the connective components were the key aspects of this technological achievement. Small, hexagonal battery cells, resembling a snake scale were connected with polymer and copper material that use a hinge mechanism to fold and unfold. This design also facilitates economical mass-production, because the battery can be made by cutting and folding flexible electrodes with a manufacturing process inspired by the art of origami.

- This new technology can be implemented in energy storage devices found in wearable soft robots for humans, which require soft and flexible energy storage devices, or for those found in rehabilitation medical devices for the elderly and the sick who need physical assistance. In addition, these batteries are expected to be useful as power supply devices for soft robots that are used on site during disasters to help conduct rescue missions. Thanks to their ability to move flexibly and freely change shape, robots equipped with these batteries can be used to access narrow spaces blocked off by obstacles during such disaster situations.

- In the future, the KIMM research team hopes to develop technology that can increase the storage capacity of soft energy storage devices. The team also hopes to develop multi-functional soft robots that combine artificial muscles with soft robot actuation technology.

- Dr. Bongkyun Jang stated that, by applying the structure and design of snake scales, the KIMM research team developed a battery that is not only safe to use, but also retains its flexibility and stretchability. He also added that, down the road, he and his team aim to continue conducting follow-up research and development, so that this technology can be used for rehabilitation medical care and disaster relief and help ensure the health and safety of the general public.

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- Attachment 1: Structure of the stretchable scale battery mimicking snake scales (image)
- Attachment 2: The stretchable snake scale-like battery (photo)
- Attachment 3: Application of the stretchable scale battery in soft robots (photo)
- Attachment 4: Application of stretchable scale battery in wearable electronic devices (photo)

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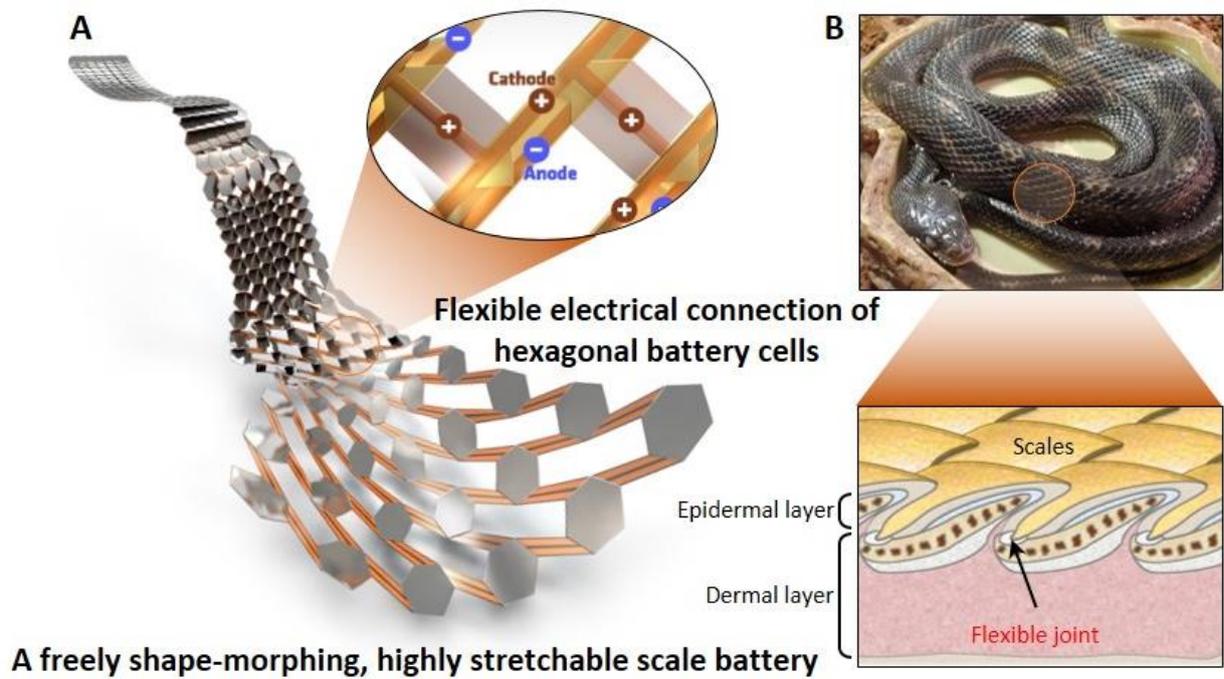
The Korea Institute of Machinery and Materials (KIMM) is a non-profit government-funded research institute under the Ministry of Science and ICT. Since its foundation in 1976, KIMM is contributing to economic growth of the nation by performing R&D on key technologies in machinery and materials, conducting reliability test evaluation, and commercializing the developed products and technologies.

These research efforts were carried out with the support of the Development of Nano-based Omni-Tex Technology Project of the KIMM, the Global Frontier Project (Center for Advanced Meta-Materials) of the Ministry of Science and ICT, and the Alchemist Project of the Ministry of Trade, Industry and Energy. The team's findings were published online in *Soft Robotics*, with the title "Bioinspired, Shape-Morphing Scale Battery for Untethered Soft Robots" (DOI: <https://doi.org/10.1089/soro.2020.0175>).

Credit : The Korea Institute of Machinery and Materials (KIMM)

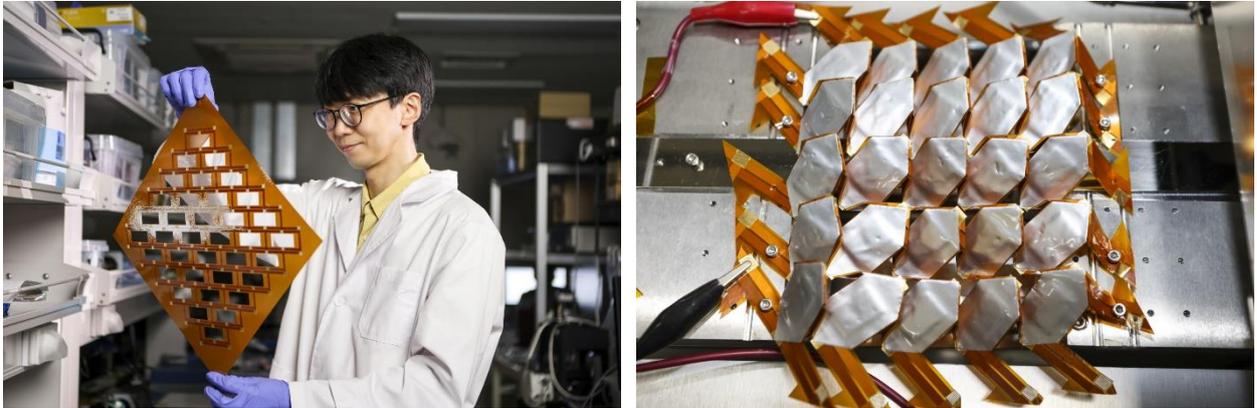
Usage Restrictions of Multimedia (Attachment File) : The sources of photos and research results from KIMM must be specified.

- Attachment 1: Structure of the stretchable scale battery mimicking snake scales (image)



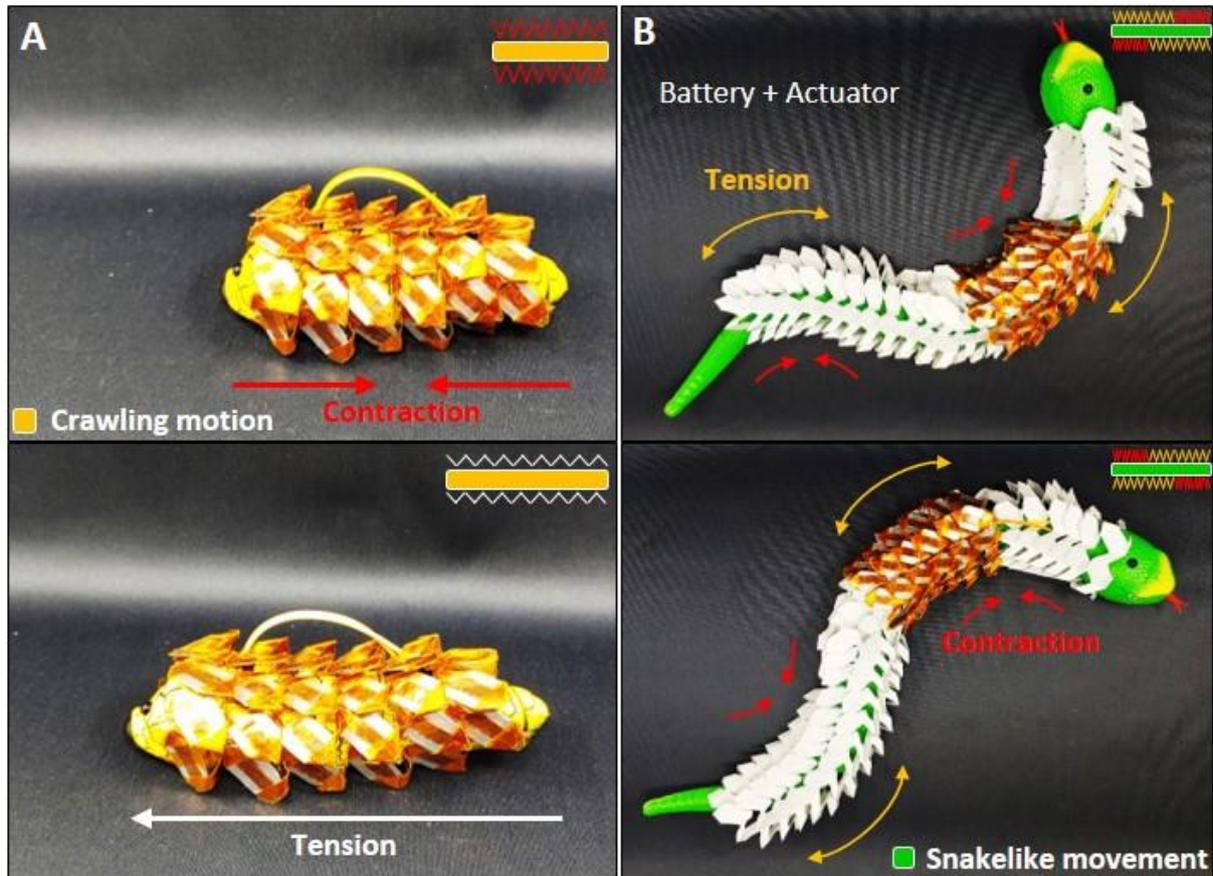
Description: The KIMM research team led by Dr. Bongkyun Jang and Dr. Seungmin Hyun at the Department of Nano-Mechanics has developed a battery with high safety and stretchability by mimicking the design of the scales and flexible joints found in the structure of snake scales. Upon zooming in on the battery, one can see that it consists of a hexagonal battery and flexible electrical interconnections. The stretchable structure is realized by the flexible interconnections that can freely fold and unfold.

- Attachment 2: The stretchable snake scale-like battery (photo)



Description: (Left) Dr. Bongkyun Jang at the KIMM Department of Nano-Mechanics checking the status of electrode-structures for producing the stretchable snake scale-like battery. (Right) Using the stretchable battery test machine with temperature and environment control units, Dr. Bongkyun Jang is testing the reliability of the battery under mechanical deformation.

- Attachment 3: Application of the stretchable scale battery in soft robots (photo)



Description: The flexible, stretchable battery technology developed by the research team of Dr. Bongkyun Jang and Dr. Seungmin Hyun at the KIMM Department of Nano-Mechanics is applied to a soft robot with moveable joints like a snake to observe its flexibility when moving. The battery can be attached to various types of robots that crawl or move in a serpentine fashion, morphing its shape accordingly depending on their movement while, at the same time, providing power to actuate untethered robots.

- Attachment 4: Application of stretchable scale battery in wearable electronic devices (photo)



Description: The flexible, stretchable battery developed by the research team of Dr. Bongkyun Jang and Seungmin Hyun at the KIMM Department of Nano-Mechanics is shown on an individual's arm and hand. The battery is not only capable of conformably attaching to the shape of the human body, but can also morph freely to match the wearer's movement.