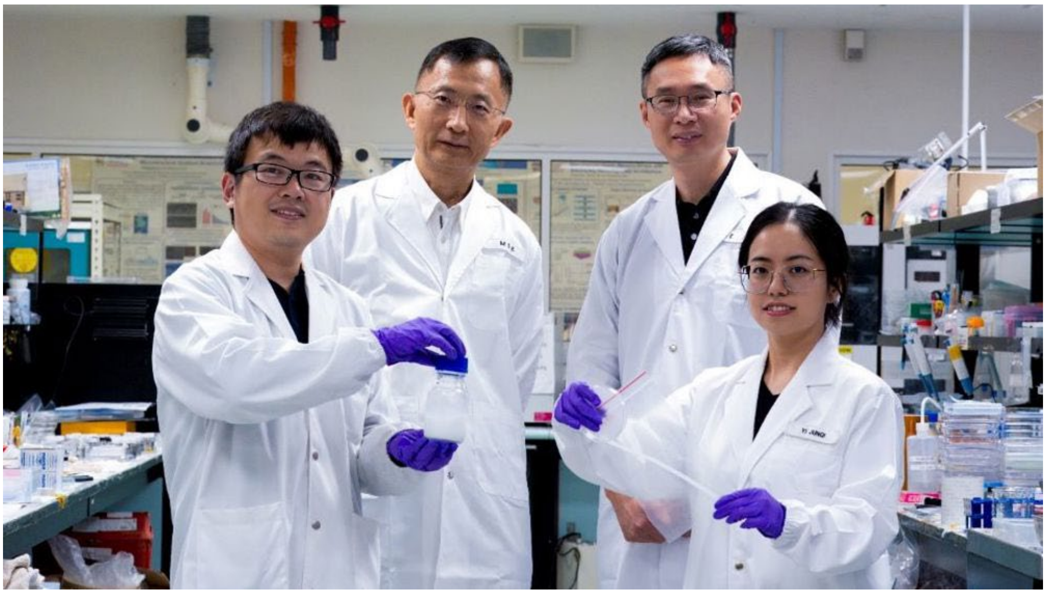
THE ENGINEER

22 February 2024

Spider-silk inspires flexible electrode implant

Scientists have taken inspiration from spider silk to develop an electrode that wraps around muscles, nerves and hearts to deliver electrical stimulation to tissues or record electrical activity.



The Singapore team behind the innovation. From left: Dr Zou Guijin, research fellow from the Institute of High Performance Computing, Agency for Science, Technology and Research; Prof Gao Huajian of NTU's School of Mechanical and Aerospace Engineering; Prof Chen Xiaodong of NTU's School of Materials Science and Engineering and Dr Yi Junqi, research fellow from NTU's School of Materials Science and Engineering and NTU's Institute for Digital Molecular Analytics and Science - NTU Singapore

The electrode contracts to conform to biological tissues, is non-toxic and performs better than conventional stretchable electrodes.

Led by a team from Nanyang Technological University (NTU) in Singapore, the innovation could lead to biomedical devices for monitoring irregular heartbeat, nerve repair, wound closure and scar reduction.

The study was led by Prof Chen Xiaodong of NTU's School of Materials Science and Engineering; Prof Gao Huajian of NTU's School of Mechanical and Aerospace Engineering; Prof Liu Zhiyuan from the Chinese Academy of Sciences; and Prof Hu Benhui from Nanjing Medical University. Their findings are detailed in *Nature*.

The electrode is made from a flexible material which contracts when wet to fit securely around tissues and organs.

Drawing inspiration from the structure of spider silk, the scientists created the material by mixing semicrystalline poly(ethylene oxide) (PEO) with poly(ethylene glycol)-α-cyclodextrin inclusion complex (IC). IC connects the PEO semicrystalline structures and holds them together.

The material was then repeatedly stretched to form a thin film. According to NTU, the stretching causes the semicrystalline PEO to create bridges and pores. Simultaneously, the semicrystalline PEO re-forms into crystals, stabilising the material in a stretched state when the film is dry.

When the dry film comes into contact with water, the water breaks and dissolves the PEO structures, causing it to contract to fit around tissues and organs.

Experiments using cell cultures showed that the material was not toxic to cells.

To create the flexible electrode, the researchers deposited gold onto the dry and stiff film before wetting it.

In experiments on rats, the researchers demonstrated that the electrode created using the film could deliver electrical impulses effectively to nerves.

The electrode can also record electrical signals from muscles, nerves and the heart, with higher sensitivity than conventional stretchable gold electrodes, thanks to the seal between the electrode and the tissue.

The scientists showed that the electrode could detect electrical activity from the stimulation of a muscle graft by a nerve, a procedure commonly used to control prosthetic limbs or treat phantom pain after limb amputation.

“Our water-responsive material may play an important role in shaping the next generation of biomedical applications at the interface between electronics and the human body,” said Dr Yi Junqi, research fellow from NTU’s School of Materials Science and Engineering and NTU’s Institute for Digital Molecular Analytics and Science, and the first author of the study.

The scientists demonstrated that the electrode could be wrapped around the rat heart to detect electrical signals resulting from abnormal heart rhythms without customising its size or shape.

To install the electrode around the heart, it is first delivered into the chest via a small incision guided by a camera. The electrode then unfolds to surround the heart for installation. When the electrode comes into contact with water in the chest cavity, it contracts to wrap around the heart.

According to the researchers, the electrode can be installed temporarily or permanently, depending on its applications.

The scientists are currently working on enhancing the long-term stability of the electrode and optimising its performance. In the future, they plan to conduct clinical trials.

https://www.theengineer.co.uk/content/news/spider-silk-inspires-flexible-electrode-implant