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7 Feb

Spider silk-inspired electrode for next-gen medical devices

A team of scientists has developed a flexible electrode that wraps around muscles, nerves and hearts to deliver electrical stimulation to tissues or record electrical activity. Inspired by spider silk, the electrode contracts to conform to biological tissues, is non-toxic and is designed to perform better than conventional stretchable electrodes. The electrode could facilitate the development of biomedical devices for monitoring irregular heartbeat, nerve repair, wound closure and scar reduction.

The electrode is made from a flexible material which contracts when wet to fit securely around tissues and organs. The material was created by mixing a compound called semicrystalline poly(ethylene oxide) (PEO) with another compound called poly(ethylene glycol)- α-cyclodextrin inclusion complex (IC). IC connects to the PEO semicrystalline structures and holds them together.

The material was then repeatedly stretched to form a thin film. The stretching causes the semicrystalline PEO to create bridges and pores. The semicrystalline PEO also 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, like shrink wrap. Experiments using cell structures showed that the material was not toxic to cells.

To create the electrode, the researchers deposited gold, which is electrically conductive, onto the dry and stiff film before it was wetted. Experiments conducted on rats 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, due 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. The electrode could also be wrapped around the rat heart to detect electrical signals resulting from abnormal heart rhythms without customising its size or shape.

The researchers installed the electrode around the heart by delivering it into the chest via a small incision guided by a camera. The electrode then unfolds to surround the heart for easy installation. When the electrode comes into contact with water in the chest cavity, it contracts to wrap around the heart. The electrode can be installed temporarily or permanently, depending on its applications. It can be easily removed when it is no longer required, or left in place if long-term monitoring or electrical stimulation is necessary.

When wet, the electrode contracts and wraps around organs and tissues. Credit: NTU Singapore.

“Being minimally invasive, our innovation could make device implantation procedures safer and simpler,” said Professor Chen Xiaodong, lead researcher from Nanyang Technological University.

The scientists are working on enhancing the long-term stability of the electrode and optimising its performance. In future, they plan to conduct clinical trials to ensure the safe use of the electrode. The research findings were published in the journal *Nature*.

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