Knitting electronics with yarn batteries

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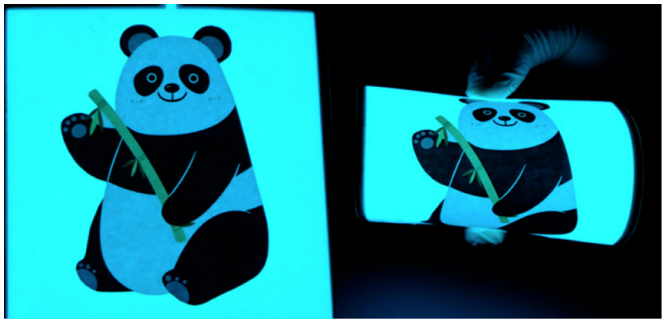

Pieces of flexible, rechargeable yarn batteries can be connected in series to power electroluminescent panel displays. Credit: American Chemical Society

When someone thinks about knitting, they usually don't conjure up an image of sweaters and scarves made of yarn that can power watches and lights. But that's just what one group is reporting in *ACS Nano*. They have developed a rechargeable yarn battery that is waterproof and flexible. It also can be cut into pieces and still work.

Most people are familiar with smartwatches, but for wearable electronics to progress, scientists will need to overcome the challenge of creating a device that is deformable, durable, versatile and wearable while still holding and maintaining a charge. One dimensional fiber or yarn has shown promise, since it is tiny, flexible and lightweight. Previous studies have had some success combining one-dimensional fibers with flexible Zn-MnO2 batteries, but many of these lose charge capacity and are not rechargeable. So, Chunyi Zhi and colleagues wanted to develop a rechargeable yarn zinc-ion battery that would maintain its charge capacity, while being waterproof and flexible.

The group twisted carbon nanotube fibers into a yarn, then coated one piece of yarn with zinc to form an anode, and another with magnesium oxide to form a cathode. These two pieces were then twisted like a double helix and coated with a polyacrylamide electrolyte and encased in silicone. Upon testing, the yarn zinc-ion battery was stable, had a high charge capacity and was rechargeable and waterproof. In addition, the material could be knitted and stretched. It also could be cut into several pieces, each of which could power a watch. In a proof-of-concept demonstration, eight pieces of the cut yarn battery were woven into a long piece that could power a belt containing 100 light emitting diodes (known as LEDs) and an electroluminescent panel.

More information: "Waterproof and Tailorable Elastic Rechargeable Yarn Zinc Ion Batteries by a Cross-Linked Polyacrylamide Electrolyte" *ACS Nano* (2018). pubs.acs.org/doi/abs/10.1021/acsnano.7b09003

ABSTRACT

Emerging research toward next-generation flexible and wearable electronics has stimulated the efforts to build highly wearable, durable, and deformable energy devices with excellent electrochemical performances. Here, we develop a high-performance, waterproof, tailorable, and stretchable yarn zinc ion battery (ZIB) using double-helix yarn electrodes and a cross-linked polyacrylamide (PAM) electrolyte. Due to the high ionic conductivity of the PAM electrolyte and helix structured electrodes, the yarn ZIB delivers a high specific capacity and volumetric energy density (302.1 mAh $g^{?1}$ and 53.8 mWh $cm^{?3}$, respectively) as well as excellent cycling stability (98.5% capacity retention after 500 cycles). More importantly, the quasi-solid-state yarn ZIB also demonstrates superior knittability, good stretchability (up to 300% strain), and superior waterproof capability (high capacity retention of 96.5% after 12 h underwater operation). In addition, the long yarn ZIB can be tailored into short ones, and each part still functions well. Owing to its weavable and tailorable nature, a 1.1 m long yarn ZIB was cut into eight parts and woven into a textile that was used to power a long flexible belt embedded with 100 LEDs and a 100 cm2 flexible electroluminescent panel.

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