ELECTROCHEMICAL ARTIFICIAL MUSCLE YARNS AND TEXTILES THAT HARVEST AND STORE ENVIRONMENTALLY AVAILABLE ENERGIES

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Mechanical energy harvesters are needed for such diverse applications as self-powered wireless sensors, structural and human health monitoring systems, and cheaply harvesting energy from ocean waves. The here reported nanofiber yarn harvesters can electrochemically convert tensile or torsional mechanical energy into electrical energy. Stretching coiled yarns generated 250 W/kg of peak electrical power when cycled up to 30 Hz, and up to 41.2 J/kg of electrical energy per mechanical cycle, when normalized to the weight of the harvester yarn. Unlike for other harvesters, torsional rotation produces both tensile and torsional energy harvesting and no bias voltage is required, even when electrochemically operating in salt water. Since homochiral and heterochiral coiled harvester yarns provide oppositely directed potential changes when stretched, both contribute to output power in a dual-electrode yarn. These energy harvesters were used in the ocean to harvest wave energy, combined with thermally-driven artificial muscles to convert temperature fluctuations to electrical energy, sewn into textiles for use as self-powered respiration sensors, and used to power a LED and to charge a storage capacitor. The development of “piezoelectrochemical spectroscopy” and insights into the hierarchical origins of capacitance increased fundamental understanding. When run in the reverse direction, these muscle types can provide powerful artificial muscles, and the same fibers used as harvesters and muscles can be used to store electrical energy. This work is collaborative with researchers at Hanyang University, University of Texas at Dallas, Lintec of America; Jiangnan Graphene Research Institute, Virginia Tech, and the Wright-Patterson Air Force Research Laboratory.