Electrochemical actuation of pristine carbon fibers

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Structures that can be stimulated to change shape have potential for various applications,[1] but they often require processing and modification.[2] We propose a simple and straightforward actuation strategy based on bipolar electrochemistry,[3] which drives asymmetric reactions at the surface grooves of pristine carbon fibers.

In the first set of proof-of-principle experiments, a free-standing carbon fiber is polarized in a closed bipolar cell to trigger asymmetric benzoquinone/hydroquinone redox reactions in two distinct compartments. Ion transfer occurs beyond a specific threshold potential, and the part of the fiber involved in the anodic reaction exhibits reversible directional motion.

Elemental surface characterization of the polarized carbon fiber suggests that the deflection results from the intercalation and deintercalation of ions accompanying the oxidation and reduction of the fiber. Simultaneous local ionic adsorption and desorption at the surface contribute to the observed motion.

The extent of fiber deflection is determined by the length of the segment exposed to the electrochemical reduction reaction in the opposite compartment of the closed bipolar cell, while the direction of motion is governed by the groove orientation. Effective bending was achieved by optimizing both fiber alignment and stimulus parameters.

The actuation of two parallel fibers oriented in opposite directions produces a microtweezer-like motion.[4] We anticipate that these findings will enrich the toolbox for research in soft robotics and micromechanics.

References

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