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SIMPLE METHOD FOR PRODUCING ARTIFICIAL NYLON MUSCLE FIBERS - PRELIMINARY EXPERIMENTS IN BIONICS

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Artificial muscles, or muscle-like actuators, mimic natural muscle by adjusting their stiffness and undergoing reversible contractions, expansions, or rotations in response to external stimuli (e.g., voltage, pressure, or temperature). The three fundamental responses of artificial muscles – contraction, expansion, and rotation – can be integrated to enable other types of motion, such as bending, achieved by contracting one side of the material while expanding the other. Unlike conventional motors or pneumatic actuators, which are multi-component devices, artificial muscles often consist of a single active component. Their remarkable flexibility, versatility, and high power-to-weight ratio make them a potentially disruptive technology with applications in various fields, including industry, medicine, robotics, and more.

Artificial muscles encompass a wide array of technologies vital in robotics, prosthetics, and various applications. Shape-memory alloys like nitinol deform upon heating and cooling. Electroactive polymers respond to electrical stimuli. Pneumatic actuators, driven by air pressure, replicate muscle contractions. Ionic and dielectric elastomers deform under electric fields. Unfortunately, due to technological challenges, the production cost of many of these devices is high, which may limit their widespread use in the industry. Due to this, alternative approaches to manufacturing various types of artificial muscles at a lower cost are being explored. One of such promising methods is the fabrication of artificial contractile fibers made from polyamide (nylon).

In the production of artificial muscles, a standard nylon fishing line with a 0.5 mm diameter was utilized. The thread was twisted under load using a spindle powered by a DC electric motor. The number of twists was determined through a spindle rotation counting system. The length of the twisted thread, the number of twists, and the load mass were adjusted experimentally, considering the efficiency of the resulting muscle. The twisted thread was then wound onto a tungsten mandrel with a 1 mm diameter, secured to prevent decoiling, and annealed for 0.5 hours at a temperature close to the softening point of nylon. It was then gradually cooled to room temperature. After removing the mandrel, the artificial muscle fiber was subjected to testing.

The factor stimulating the contraction of the nylon fiber is an increase in temperature. The artificial nylon muscle was found to contract by up to 20% of its original length. A single artificial muscle fiber generated a maximum force of 0.65N +/- 0.10N during continuous operation lasting at least 5 seconds. On average, a single muscle performed work of W = 12mJ +/- 0.12mJ, displaying a power density of around 90W/kg. The results suggest that such artificial muscle fibers could be useful in many applications, and further research in this direction is worthwhile.