Biomaterial Fiber-Reinforced Actuators Move Soft Robotics Beyond Silicone

Scientific Achievement

In this work, a CINT User Team establishes bioFREEs as a viable replacement for silicone systems, achieving comparable pressures, forces, and durability while introducing biocompatible and sustainable materials into soft robotics.

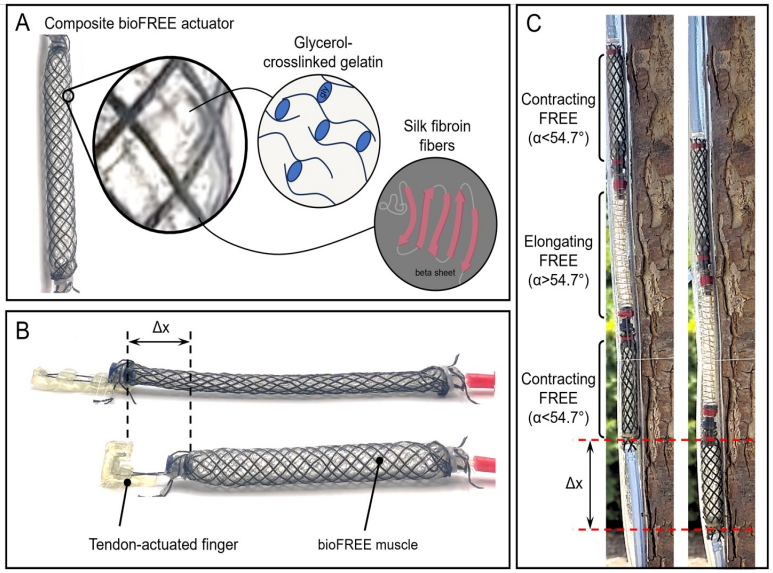

Figure: Protein-based, silk-reinforced gelatin bioFREE actuator. **(A)** BioFREE actuators are composed of glycerol-crosslinked gelatin wrapped with silk fibroin fibers. **(B)** Demonstration of a finger-like mechanism made of bioFREE and protein-based tendon actuators. **(C)** A series of contracting and elongating bioFREEs climbing down a tree using peristaltic motion.

Significance and Impact

Soft actuators are critical for compliant robot function but are typically made of synthetic materials, limiting applicability in contaminable environments (e.g., agricultural, biomedical). To address this need, fully protein-based pneumatic actuators (bioFREEs) were developed for directional motion control and increased payload-to-weight ratio.

Research Details

- Gelatin-silk fibroin composites are formed in 3D-printed molds across varying compositions to elucidate structure–property relationships.
- BioFREE actuators achieve up to ~96.5 kPa internal pressure, ~17% contraction, ~30 N blocked force, a payload-to-weight ratio of ~519, and demonstrate durability over ≥40,000 cycles at 82.7 kPa without failure.

Work was performed, in part, at the Center for Integrated Nanotechnologies.

Edward, S.; Wilcoski, D.; Taylor, N.; Robinson, J.; Kaehr, B.; Krishnan, G.; Golecki, H. M. Engineering Protein-Based Fiber-Reinforced Pneumatic Actuators. *RSC Applied Polymers.* 2026.