Natural Rubber-Based Soft Robotic Gripper with Tunable Performance

Natural rubber (NR) offers a sustainable and mechanically robust alternative to synthetic elastomers for soft robotics, but its broader adoption has been limited by challenges in fabricating the intricate geometries required for advanced actuator architectures. In this work, we employ a gelling-assisted latex casting process with 3D-printed molds to reliably fabricate NR-based actuators with varied geometric parameters and systematically investigate their actuation behaviors. Under pneumatic actuation, bending efficiency and sensitivity of the actuator increased with chamber number and height, resulting in enhanced gripping performance, whereas increased chamber wall thickness suppressed actuation and grasping capability. To assess the influence of material stiffness, actuators fabricated from NR with different crosslink densities were further examined. Actuators with lower crosslink density exhibited greater bending ability and higher sensitivity at low actuation pressures, whereas higher crosslink density enhanced mechanical stiffness and burst resistance, enabling stable operation at elevated pressures. As a result, actuators with low, medium, and high crosslink densities achieved maximum gripping forces of 10.85, 11.99, and up to 18.25 N at actuation pressures of 125, 150, and 200 kPa, respectively.

These findings demonstrate that the actuation performance of NR-based soft robotics can be precisely tailored through the synergistic optimization of geometric design and rubber network structure. Finally, a four-arm soft gripper assembled from the optimized NR actuators effectively manipulated a range of delicate objects, highlighting the potential of NR as a sustainable and versatile material for next-generation soft robotic systems.

The associated SDG goal is Industry, Innovation and Infrastructure (9).

For more information: Manus Sriring (manus.sri@mahidol.ac.th)

Reference:

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