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Soft Pneumatic Actuators Fabricated Using Soluble Polymer Inserts and a Single-Pour System for Improved Durability

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Abstract : Although a relatively new field, soft robotics is experiencing a rise in applicability in the secondary school setting through The Soft Robotics Toolkit, shared fabrication resources and a design competition. Exposing students outside of university research groups to this rapidly growing field allows for development of the soft robotics industry in new and imaginative ways. Soft robotic actuators have remained difficult to implement in classrooms because of their relative cost or difficulty of fabrication. Traditionally, a two-part molding system is used; however, this configuration often results in delamination. In an effort to make soft robotics more accessible to young students, we aim to develop a simple, single-mold method of fabricating soft robotic actuators from common household materials. These actuators are made by embedding a soluble polymer insert into silicone. These inserts can be made from hand-cut polystyrene, 3D-printed polyvinyl alcohol (PVA) or acrylonitrile butadiene styrene (ABS), or molded sugar. The insert is then dissolved using an appropriate solvent such as water or acetone, leaving behind a negative form which can be pneumatically actuated. The resulting actuators are seamless, eliminating the instability of adhering multiple layers together. The benefit of this approach is twofold: it simplifies the process of creating a soft robotic actuator, and in turn, increases its effectiveness and durability. To quantify the increased durability of the single-mold actuator, it was tested against the traditional two-part mold. The single-mold actuator could withstand actuation at 20psi for 20 times the duration when compared to the traditional method. The ease of fabrication of these actuators makes them more accessible to hobbyists and students in classrooms. After developing these actuators, they were applied, in collaboration with a ceramics teacher at our school, to a glove used to transfer nuanced hand motions used to throw pottery from an expert artist to a novice. We quantified the improvement in the users' pottery-making skill when wearing the glove using image analysis software. The seamless actuators proved to be robust in this dynamic environment. Seamless soft robotic actuators created by high school students show the applicability of the Soft Robotics Toolkit for secondary STEM education and outreach. Making students aware of what is possible through projects like this will inspire the next generation of innovators in materials science and robotics.

Keywords : pneumatic actuator fabrication, soft robotic glove, soluble polymers, STEM outreach
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