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Multifunctional Graphene Oxide Origamis with Morphable Reconfiguration

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ABSTRACT

Responsive materials capable of converting various forms of energy into mechanical work have applications in diverse areas such as soft robotics, biomedical devices, sensing, and morphing structures. Among these materials, graphene oxide (GO) stands out due to its exceptional responsiveness to light, heat, and humidity. Despite recent progress, GO-based actuators often encounter challenges such as slow response times, limited functionalities, and environmental incompatibilities. Here, a novel magnetic GO (MGO) bilayer actuator is reported, incorporating hard-magnetic microparticles to enhance actuation capabilities through a magnetic field, offering fast response, precise control, and stability in aqueous environments. The MGO film enables a low-cost and straightforward fabrication of customized geometries through post-fabrications including cutting, origami folding, and sticking, facilitating complex structures morphing and versatile functionalities under magnetic actuation. A high-throughput and low-energy-consumption magnetization programming strategy based on arrangements of reusable MGO magnetic stickers is introduced for the multimodal shape morphing and reconfiguration. The diverse functionalities derived from magnetically-actuated shape morphing of MGO structures are further exploited for applications including an in-situ mechanical mode transition in origami structure, sequential logic computing, and soft robots capable of climbing over obstacles, swimming, and on-ground and in-water locomotion.