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Journal Club:

Liquid-induced topological transformations of cellular microstructures

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Abstract

The fundamental topology of cellular structures—the location, number and connectivity of nodes and compartments—can profoundly affect their acoustic, electrical5, chemical, mechanical, and optical properties, as well as heat fluid and particle transport. Approaches that harness swelling electromagnetic actuation and mechanical instabilities in cellular materials have enabled a variety of interesting wall deformations and compartment shape alterations, but the resulting structures generally preserve the defining connectivity features of the initial topology. Achieving topological transformation presents a distinct challenge for existing strategies: it requires complex reorganization, repacking, and coordinated bending, stretching and folding, particularly around each node, where elastic resistance is highest owing to connectivity. Here we introduce a two-tiered dynamic strategy that achieves systematic reversible transformations of the fundamental topology of cellular microstructures, which can be applied to a wide range of materials and geometries. Our approach requires only exposing the structure to a selected liquid that is able to first infiltrate and plasticize the material at the molecular scale, and then, upon evaporation, form a network of localized capillary forces at the architectural scale that 'zip' the edges of the softened lattice into a new topological structure, which subsequently restiffens and remains kinetically trapped. Reversibility is induced by applying a mixture of liquids that act separately at the molecular and architectural scales (thus offering modular temporal control over the softening–evaporation–stiffening sequence) to restore the original topology or provide access to intermediate modes. Guided by a generalized theoretical model that connects cellular geometries, material stiffness and capillary forces, we demonstrate programmed reversible topological transformations of various lattice geometries and responsive materials that undergo fast global or localized deformations. We then harness dynamic topologies to develop active surfaces with information encryption, selective particle trapping and bubble release, as well as tunable mechanical, chemical and acoustic properties.

The paper can be accessed via: https://www.nature.com/articles/s41586-021-03404-7

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