Effect of mechanical properties on multicomponent shell patterning

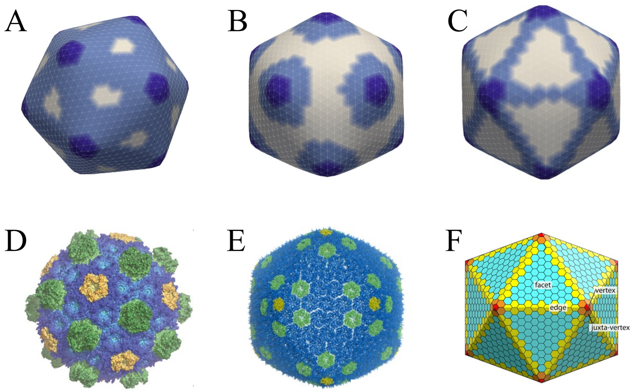

Figure 1: (A)-(C) Simulation snapshots of three components distribution patterns on a buckled closed shell. While the softest bending component (dark blue) occupies the buckling vertices, the harder bending components (blue and white) form spots, circular and ridge patterns depending on the bending rigidity ratio and the stoichiometric ratio. (D)-(E) Experimental models of bacterial microcompartments. The multiple types of protein components are distributed in spots, circular and ridge patterns.

Siyu Li, Daniel A. Matoz-Fernandez, and Monica Olvera de la Cruz. Submitted to ACS Nano (2021).

Work was performed at Northwestern University

Scientific Achievement

This work reveals the mechanism of the pattern formation on a buckled icosahedral shell composed of multiple components. Through a computational approach, spots, circular and ridge patterns are obtained by varying the heterogeneous bending rigidities, resembling the protein distributions observed in bacterial microcompartments.

Significance and Impact

This work elucidates the principles of pattern formation that can be used to design and engineer bacterial microcompartments with specific distribution of the components.

Research Details

- We first analyze the two-component pattern distribution on an isolated portion of a shell (a cone) through the continuum elasticity theory.
- We then perform Monte Carlo simulations and investigate the impact of bending rigidities, stoichiometric ratio and line tension on the surface patterns of the cone and a closed shell.
- We finally simulate a three-component closed shell and show that the minimization of the elastic energy of a shell with multiple components with different mechanical properties leads to rich surface patterns.
- We further discuss the role of other mechanical factors such as Young's modulus and spontaneous curvature.

U.S. DEPARTMENT OF ENERGY | Office of Science

Northwestern