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Colloidal assembly: Understanding the electric field driven assembly of colloids and its applications (Science Mission Directorate)

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The project's primary objective is to establish Louisiana State University (LSU), Tulane University, Louisiana Tech University (LaTech), and Baton Rouge Community College (BRCC), along with the State of Louisiana, as leaders in the field of electric field-driven soft matter research. This will be achieved through an investigation into colloidal assembly both on Earth and in microgravity environments. The ultimate goal is to provide fundamental insights into the field-driven assembly process in confinement which will form the basis to develop innovative technologies such as rapid microcrack repair. The ability to interlock colloidal assemblies developed in this proposal will provide a path to develop highly desirable microcrack repair technologies, enabling NASA to address damage sustained by space vehicles and telescopes due to micrometeoroid encounters. Additionally, two prominent companies, Advano and Intralox, have expressed interest in collaborating on this project. They aim to adapt the research to prevent thermal runaway reactions in lithium-ion batteries and create polymer/colloid composites with enhanced mechanical properties.

The research focuses on understanding, controlling, and directing the assembly of microparticles, a process governed by intricate non-equilibrium, long-range, and competing interactions. The ability to precisely manipulate these interactions in a programmable manner is pivotal for tailoring soft microstructures and developing reconfigurable materials. However, our understanding of how microgravity influences colloidal assembly remains limited, primarily due to the challenge of decoupling gravitational forces from externally applied forces (e.g., electrical or magnetic) during the assembly process. To address this knowledge gap, the collaborative team from LSU, Tulane, LaTech, BRCC, and NASA's Glenn Research Center (GRC) will work towards gaining a comprehensive understanding of the directed assembly and transport of soft colloidal particles driven by electric fields, both on Earth and in microgravity. This research aligns with NASA's priorities, as highlighted in the FY23 NASA EPSCoR Research notice of opportunity and the 2023 BPS's decadal survey, emphasizing the importance of advancing knowledge in soft condensed matter and systems far-from-equilibrium.

The project's goals are as follows:

Goal 1: Investigate the effects of confinement, electric field strength, microgravity, and particle shape on the electric-field-driven assembly of colloids into reconfigurable structures.

Goal 2: Analyze the relative impact of inter-colloidal adhesion and friction forces on the structure and dynamics of the field-directed assembly process.

Goal 3: Develop chemical strategies to interlink electric-field-assembled particles, creating mechanically stable and robust colloidal aggregates.

Goal 4: Construct laboratory-based prototypes to demonstrate the self-repairing capability of colloidal dispersions energized by electric fields.

Goal 5: Provide opportunities to students at Minority Serving Institutes by offering paid research internship in team's laboratories and supporting their visits to NASA-GRC

Systematic experiments will utilize model colloids with engineered shapes and surface-grafted polymers with tunable thermal responses. These experiments will be conducted under both gravity and within drop towers at NASA-GRC.