Space Manufacturing: Materials Chemistry for Fabrication of High-Performance Composites

Manufacturing in space presents unique challenges and opportunities, requiring materials that are not only high-performing but also safe, efficient, and sustainable. This lecture explores the chemistry of reactive polymer processing in both terrestrial and Low Earth Orbit (LEO) environments, focusing on our development of next-generation resins tailored for space-based fabrication.

Our approach targets monomers sourced from abundant petrochemical waste streams, formulated into resins that are liquid at room temperature, non-toxic, and safe for handling, with high flash points and extended shelf stability. These resins are engineered for frontal ring-opening metathesis polymerization (FROMP), enabling rapid, energy-efficient curing without ovens – an essential advantage for space manufacturing. The resulting composites offer high stiffness and strength, superior oxidative resistance, and elevated glass transition temperatures (Tg), making them competitive with the best polymers available today. Furthermore, they are designed for deconstruction and reuse, aligning with circular materials principles crucial for sustainable in-space fabrication.

As part of Mission Illinois, our first in-space demonstration will take place in April 2026 in collaboration with Voyager Space. This experiment, launching aboard NASA's Commercial Resupply Mission NG-24 to the International Space Station (ISS), will be conducted in the Bishop Airlock module. Mission Illinois represents a major step in testing the viability of FROMP-based composite manufacturing in LEO, advancing in-situ production capabilities that could revolutionize space exploration. By enabling the fabrication of high-performance materials beyond our planet, this work helps pave the way for a more autonomous and sustainable future in space.