CIF 25-5: Biomanufacturing PLA for Surface System In-Space Construction

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Activity Type: New Start

Primary STMD Taxonomy: TX06 Human Health, Life Support, and Habitation Systems

Start TRL: 1 **End TRL:** 3

Executive Summary: Long-duration space missions and early planetary habitation will require practical and novel methods for manufacturing essential materials in situ to reduce the dependency of Earth supplied materials as referenced in the 2024 NASA Decadal Survey. To address this NASA mission critical gap, researchers at NASA's Kennedy Space Center (KSC) utilized a custom, continuous-flow fermentation membrane bioreactor (FMBR), recently developed through the Defense Advanced Research Projects Agency (DARPA)'s Biomanufacturing: Survival, Utility, and Reliability beyond Earth (B-SURE) Program, to convert alternative feed stocks (such as wastewater) via bioengineered microbes into high-value products. This approach leverages and adapts the FMBR to utilize nutrient-rich permeate from the anaerobic phototrophic membrane bioreactor (APMBR) system designed under NASA's Mars Campaign Office (MCO) Program's Bioregenerative Life Support System (BLiSS) portfolio. This CIF project develops a unique biomanufacturing method to produce polylactic acid (PLA) from wastewater derived resources, directly supporting NASA STMD's Live and Expand objectives and lunar architecture development program. PLA serves as a critical polymer binder for regolith-based 3D printing, enabling construction of habitats on the Moon and Mars utilizing in situ resources. Within the FMBR, genetically engineered lactic acid (LA)-producing microbes convert the permeate into LA, which is then polymerized into PLA using commercial off-the-shelf (COTS) post-purification and processing methods. This unique method integrates an ultrafiltration membrane system to support continuous product recovery, biomass retention, and precise control of microbial growth conditions, making it well-suited for space operation. This configuration demonstrates the feasibility of synthesizing LA from simulated recycled wastewater and establishes a template for future microbial fermentation processes such as pharmaceuticals, polymers, and other high-value products. By leveraging in situ resources and waste recycling, this project advances STMD's Live and Expand objectives by lowering mission costs and enhancing the self-sufficiency of future lunar and Martian habitats.