SUMMARY FOR PUBLIC RELEASE

Project Title: Advanced Algal Biofoundries for the Production of Polyurethane Precursors

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For algae-derived biofuels to be cost-competitive with fossil fuels, the algae industry is investing in the production of secondary high-value products and markets, including algae-based polymers. A number of the building block chemicals for polymers are ideally suited for production in cyanobacteria or algae, which naturally accumulate hydrocarbons. We propose to develop novel algae platforms for the production of polymer precursors, while simultaneously developing basic tools to enable improved algal production systems that will accelerate the process from initial concept to market supply. In the initial stages of the project, the Mayfield, Burkart, and Simkovsky groups at UCSD and the Atsumi group at UC Davis will develop preliminary production platforms. These platforms will be validated using mass spectrometry techniques that include a real-time headspace monitoring system developed by the Pomeroy and Simkovsky groups at UCSD. In collaboration with Agile BioFoundry members at Lawrence Berkeley National Laboratory and Pacific Northwest National Laboratory, we will design and construct advanced synthetic biology tools, including promoter libraries optimized through machine learning, and expand our current metabolic models of algal growth to better direct carbon flow to enhance production of target chemicals. Simultaneously, we will work with the Peralta-Yahya lab at the Georgia Institute of Technology to develop biosensors that will enable subsequent high-throughput screens for increased product yields, brought about from engineered or mutated pools of cells, including a bar-coded transposon insertion library in cyanobacteria. In the final stages of the project, we will integrate the knowledge learned from these screening and modeling experiments to generate optimized, high yield production strains of algae and cyanobacteria. These optimized strains will be field tested for target yields greater than 20 g/L under photosynthetic growth conditions, as well as under heterotrophic conditions in a fermenter using cellulosic-derived sugar feedstocks. Polycultures of production platforms will also be explored. Field test data will inform techno-economic and life-cycle analyses performed by the Kendall group at UC Davis. In generating algal bio-production systems capable of producing polymer precursors at commercially viable titers, not only can we begin to replace petroleum-based chemicals in polyurethane manufacturing with renewable alternatives, but we will have also demonstrated a novel combination of tools and technologies in an improved pipeline for bioproduction platform development that can succeed in a 3-year time frame, in contrast to the current best of a 5-year time frame. This pipeline and the resulting algal chemical production systems will provide a foundation for industrial algal bio-production. These efforts will be supported by our cost share partners, Algenesis Materials, Reef, and Arctic Foam, and additional commercial partners, Adidas and Thermo Fisher Scientific.