Versatile Synthesis Platforms for Advanced Biomanufacturing (VESPA)

Xiaokun (Claire) Yang, Raul Gonzalez Esquer, William Kubic, Babetta L. Marrone | Los Alamos National Laboratory

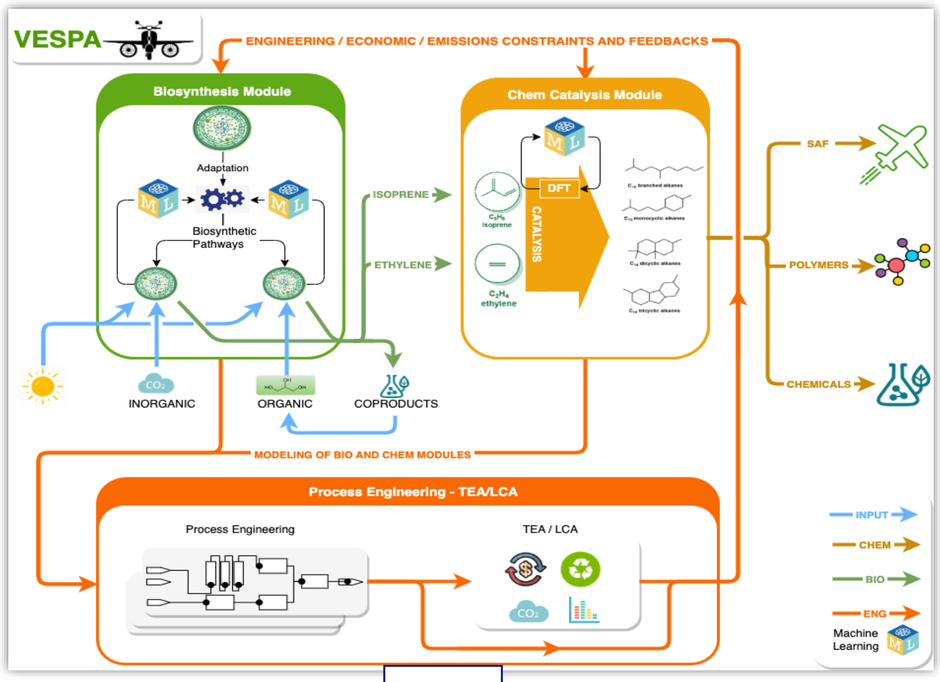
Background

BIOMANUFACTURING, SAF GRAND CHALLENGE, ECONOMICS

Develop an innovative biomanufacturing platform to produce high yields of biomolecules to biofuels, bio-chemicals, and bio-materials in a manner that is:

a. **Reliable**
b. **Affordable**
c. **Energy efficient**

AN INTEGRATED BIOMANUFACTURING SYSTEM



NATIONAL SECURITY SCIENCE PODCAST

"Jet fuels take off: Researchers aim to advance the aviation industry."

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Bio Module

INNOVATIONS IN SYNTHETIC BIOLOGY

1 Direct production in a cyanobacterial chassis

Synechococcus elongatus, PCC 7942 → Isoprene

Validated isoprene production

2 Indirect production via sucrose secretion

Isoprene + Sucrose → *E. coli*; *C. necator*

10x yield ↑ on isoprene production

3 High-performance cell-free system design

AI/ML → Isoprene

Validated > 200 combinations of enzymes

4 Co-products utilization and recycling

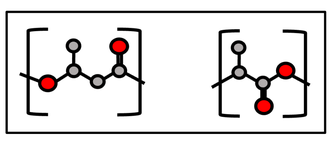
Co-products → $

Extra value added to the platform

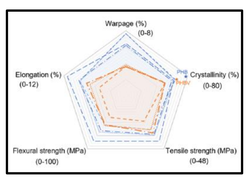
INNOVATIONS IN MODELING

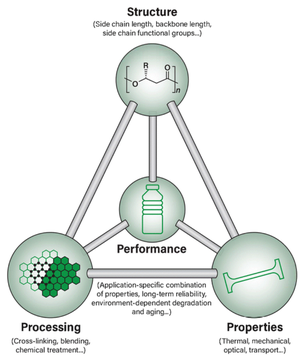
Machine Learning Tools:

Predict PHA (co)polymer Properties and performance



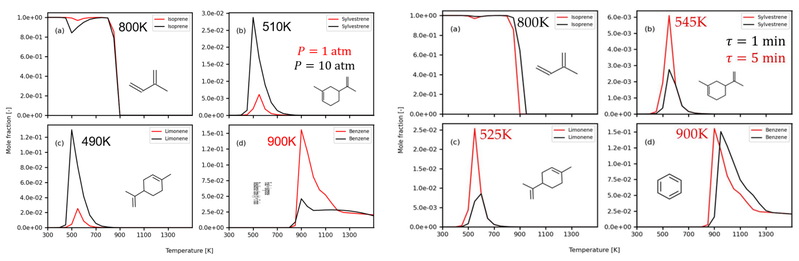
Polym. Chem., 2025, 16, 235-265





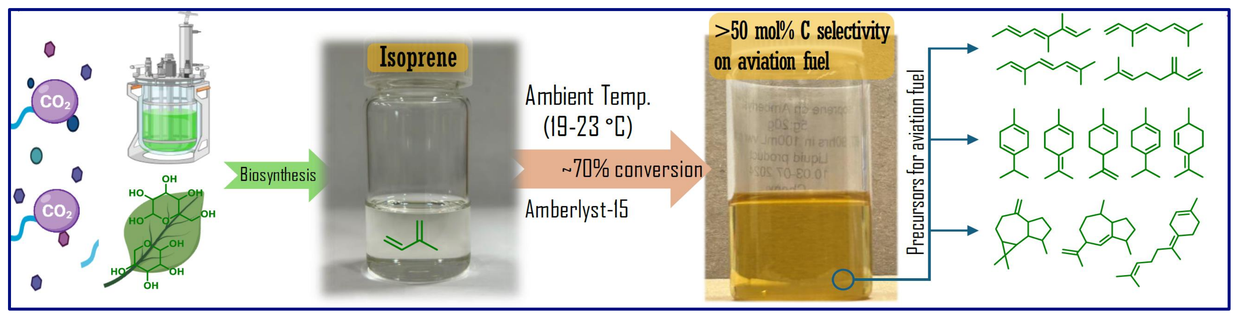
DFT Simulations:

- Thermodynamically favorable
- Longer residence time
- Higher pressure

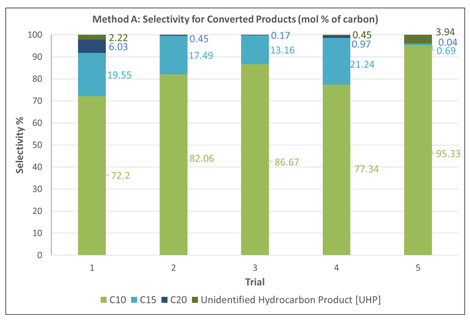


Chem Module

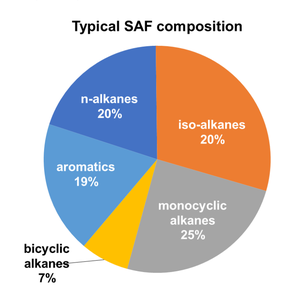
INNOVATIONS IN CATALYTIC CHEMISTRY



ACS Sustainable Chem. Eng. 2025, 13, 34, 13870–13878

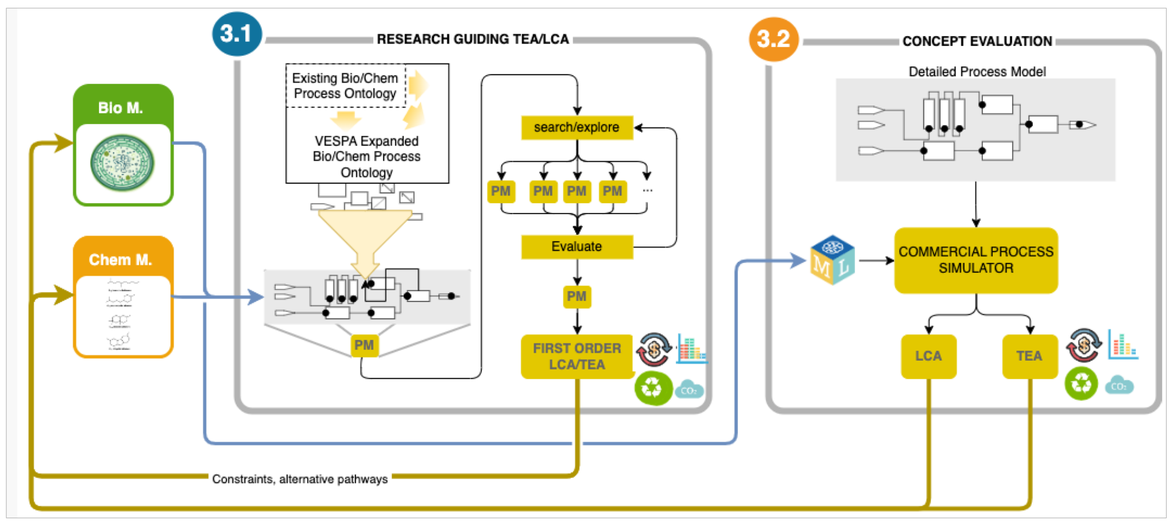


Test Sample	Higher Heating Value (HHV) [kJ/kg]
Commercial Aviation Fuel	45.5 - 46.2
Experimental Product	45.83



Engineering Module

ENGINEERING and ECONOMICS

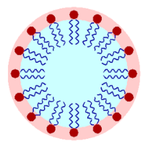


E3 Module Workflow

Impacts COLLABORATION ENABLING PROGRAM DEVELOPMENT

(LDRD)
Rare Earth Elements/ Critical Mineral Materials

(LDRD)
Bio-degradable Oil Herder



(TCF)
Renewable Surfactant

(SPP)
Renewable Natural Gas (RGN)

WORKFORCE DEVELOPMENT

Scientists and Technologist:
Shounak Banerjee (B-GEN)
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ACKNOWLEDGMENT

This work was supported by the LDRD Program at LANL, 20240001DR

LABORATORY DIRECTED RESEARCH & DEVELOPMENT

LA-UR# LA-UR-25-29623

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Abstract: Yang (LANL)

Aviation requires a secure and reliable supply of high-performance liquid fuels, making domestic production essential to U.S. energy security and economic competitiveness. The VESPA project integrates biosynthesis with versatile catalytic conversion pathways to transform abundant, domestically sourced feedstocks into multiple aviation-fuel components. This poster focuses on converting biologically derived intermediates into hydrocarbons with properties suitable for jet-fuel blending, while also producing valuable co-products such as polymers and surfactants. Supported by process engineering and techno-economic analysis, the platform aims to maximize feedstock utilization, strengthen domestic manufacturing, reduce reliance on foreign imports, and establish resilient supply chains for fuels and chemicals.