JBEI
Joint BioEnergy Institute

Deconstructing poplar lignin from ionic liquid pretreatment for biological conversion through sulfonation and Fenton chemistry

Background/Objective

- Lignin valorization is a vital aspect of biomass conversion.
- Prior work has shown Fenton chemistry to be very effective at cleaving the C-C bonds present in lignin.

Approach

- Poplar lignin isolated from a cholinium lysinate ionic liquid pretreatment was sulfonated and then treated with a Fenton reaction.
- Explored the tradeoff between the extent of deconstruction and the amount of carbon lost as CO2.

Results

- The post-Fenton depolyermization products are rich in acid, aldehyde, alcohol, and sulfonate functionalities.
- Five microorganisms were tested for growth using the lignin breakdown products as the sole carbon source and showed robust growth.

Significance/Impacts

- Fenton chemistry efficiently depolymerizes lignin into bioavailable intermediates.
- Industrial application of this process may also require removing and recycling iron from the product stream.

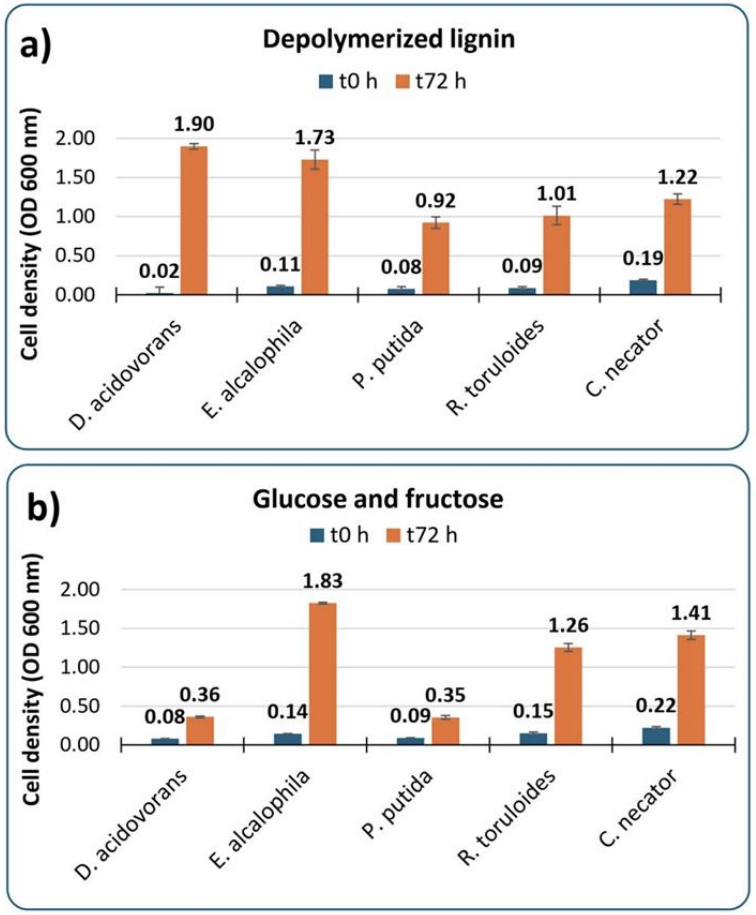

Figure: Growth of five microorganisms on medium containing depolymerized lignin, sugars, or no additional substrate. (a) lignin from case III at a concentration of 43 g L−1; (b) a mixture of glucose and fructose (2 g L−1 each).

Martinez D.V., et. al. RSC Sustainability. doi: 10.1039/D5SU00039D (JBEI #1215)

JBEI
Joint BioEnergy Institute

A polyketide-based biosynthetic platform for diols, amino alcohols and hydroxy acids

Background/Objective

- Background: Medium-/branched-chain diols are valuable industrial chemicals, challenging to biosynthetically produce.
- Objective: This study aimed to develop a modular polyketide synthase (PKS)-based biosynthetic platform to efficiently produce diols, amino alcohols, and hydroxy acids.

Approach

- Engineering PKSs with thioreductases (TRs) for aldehyde termination and conversion to diols and other chemicals;
- Replacing malonyl-CoA-specific acyltransferases with branched-chain-specific acyltransferases to enable production of branched-chain derivatives.

Results

- The engineered PKS platform enabled microbial production of nine 1,3-diols, including the insect repellent 2-ethyl-1,3-hexanediol;
- Tuning the system produced six amino alcohols and two hydroxy acids with high titers and efficient product profile control.

Significance/Impacts

- This PKS-TR-based platform offers a versatile and tunable approach for biosynthetic production of valuable specialty chemicals;
- The work expands the PKS engineering toolkit, demonstrating its potential for scalable biomanufacturing.

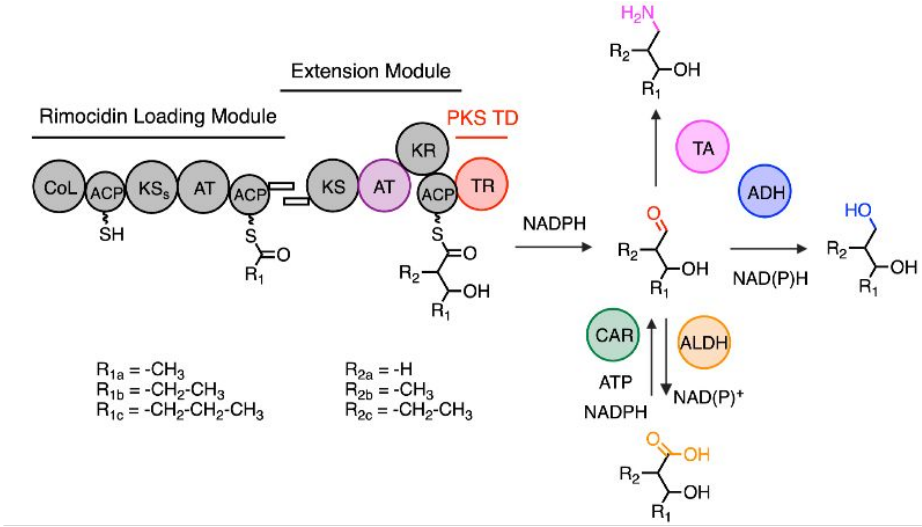

Figure: Schematic representation of the rimocidin PKS-TR platform in *Streptomyces albus*.

Dan Q., et. al. Nat Catal. doi: 10.1038/s41929-025-01299-5 (JBEI #1216)

JBEI
Joint BioEnergy Institute

Microbial Pathways for Cost-Effective Low-Carbon Renewable Indigoidine

Background/Objective

- Indigoidine is a platform molecule with applications incl. textile dye, biotransistor, biosolar cell, biosensor, and food coloring.
- Multiple microbial hosts and carbon sources that can be used

Approach

- Conduct TEA and LCA specific to each potential host and carbon source (sugars vs. sugars & aromatics)

Results

- P. putida currently outperforms synthetic indigo production and other indigoidine-producing hosts w/ MSP of $2.9/kg and 3.5 kg CO2e/kg
- Microbes that co-utilize aromatics are advantageous for cost, hosts that coproduce other value-added molecules are beneficial for emissions

Significance/Impacts

- Assessing host performance to understand tradeoffs between C source utilization vs. TRY metrics provides a useful new perspective

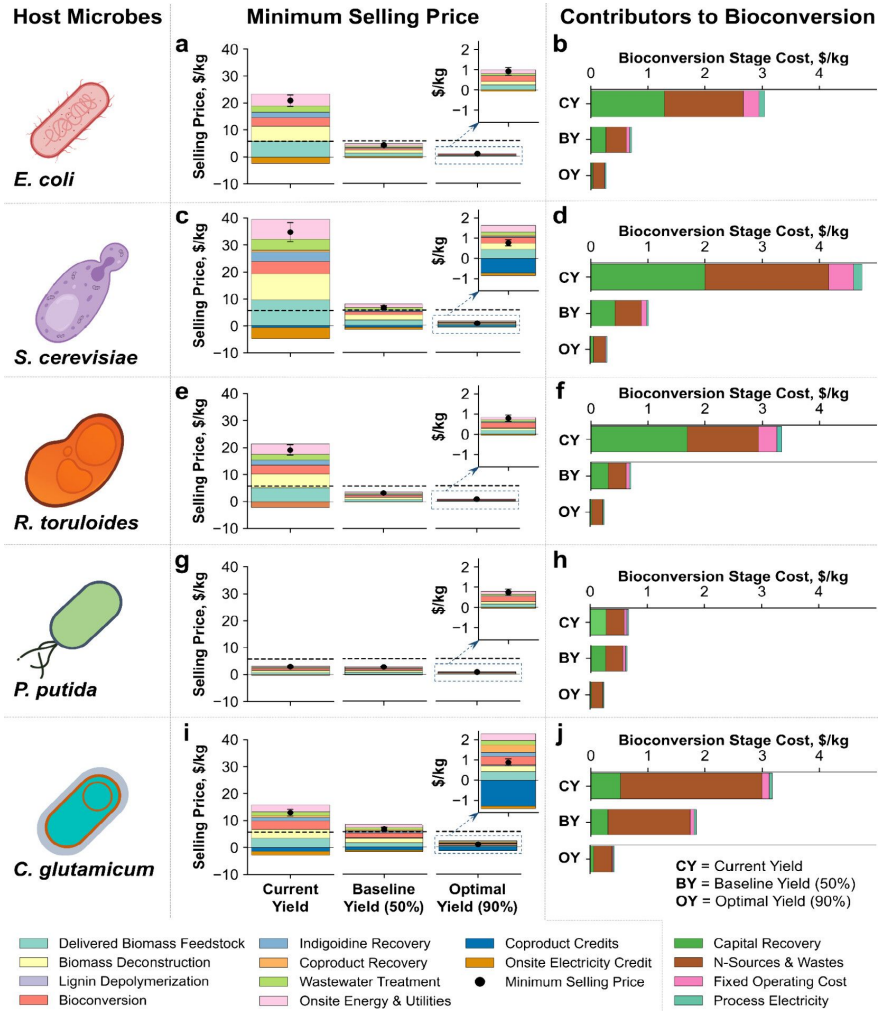

Figure: Minimum selling price of indigoidine with different host microbes utilizing only sugars, and sugars and aromatics

Baral N., et. al. ACS Sustainable Chemistry & Engineering. doi: 10.1021/acssuschemeng.4c09962 (JBEI #1217)

JBEI
Joint BioEnergy Institute

CRISPRi-ART enables functional genomics of diverse bacteriophages using RNA-binding dCas13

Background/Objective

- Phages are predominantly composed of genes of unknown function, severely limiting our ability to engineer them.
- Develop effective genome-scale phage functional genomics pipeline using RNA-binding CRISPRi-ART.

Approach

- Conducted transcriptome-scale screens on diverse phages to map essential phage genes in high-throughput.

Results

- Demonstrated programmable translation interference strongly inhibits infection of E. coli by diverse phages.
- Identified key essential genes of known and unknown function governing infectivity by model and non-model phages.

Significance/Impacts

- The first scalable platform for phage functional genomics.
- Provides blueprint for engineering non-model phages as DNA delivery vehicles for targeted microbiome editing.

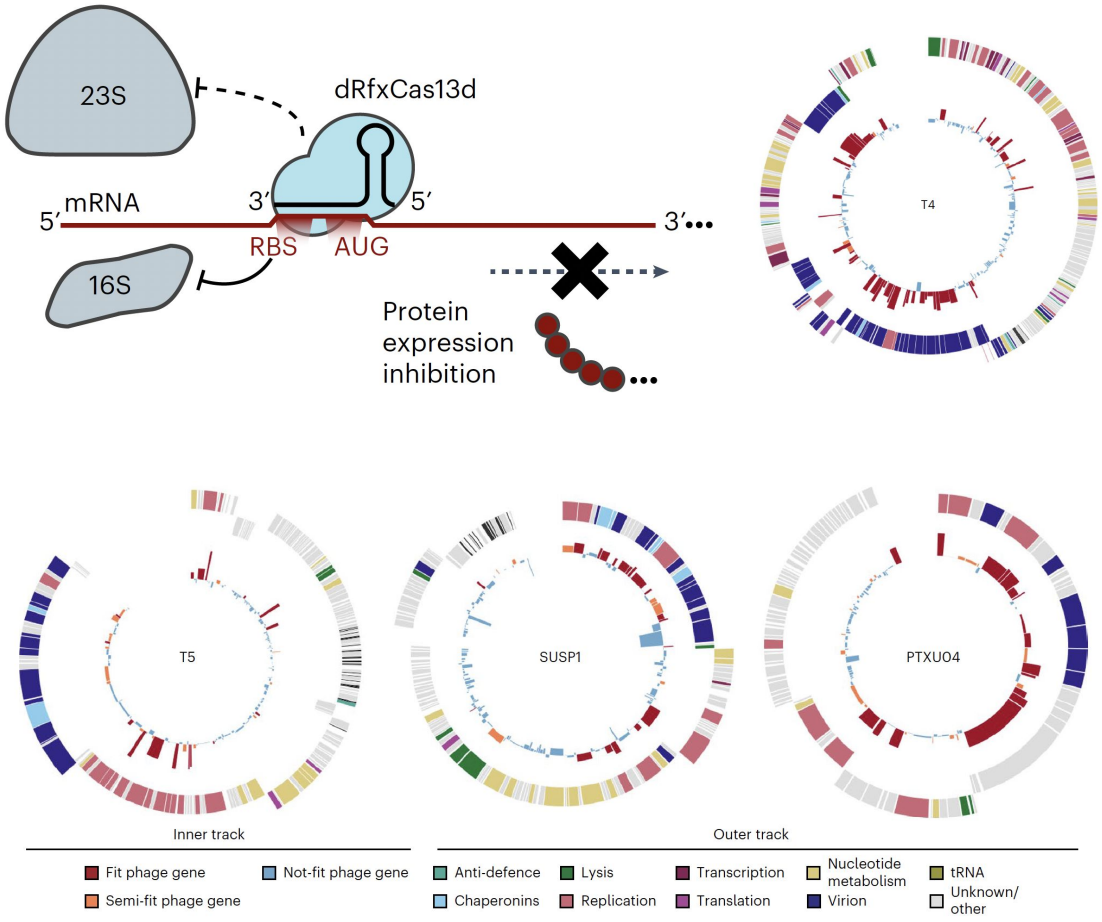

Figure: Programmable translation inhibition facilitates genome-scale phage functional genomics.

Adler B.A., et. al. Nature Microbiology. doi: 10.1038/s41564-025-01935-7 (JBEI #1218)

JBEI
Joint BioEnergy Institute

Elucidating the Role of Water on Limonene Oxidation with H2O2 over γ-Al2O3

Background/Objective

- Limonene target biological compound opening access to many value-added molecules.
- Efficient oxidation to limonene oxide key to oxygenated products.
- Reaction known but role of water unknown.

Approach

- Extensive experimental kinetic analysis to explore how water impacts the reaction.

Results

- Unlike previous speculation in the literature, water was found to directly play a role inhibiting the oxidation reaction network by consuming active sites on the catalyst.

Significance/Impacts

- An alternative oxidant to H2O2 will need to be found to enhance activity and selectivity for the reaction of limonene to limonene oxide.

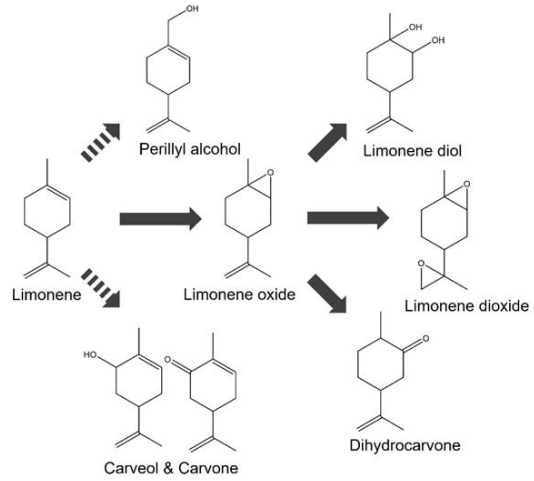

Figure 1: Reaction network from limonene to oxidized derivatives.

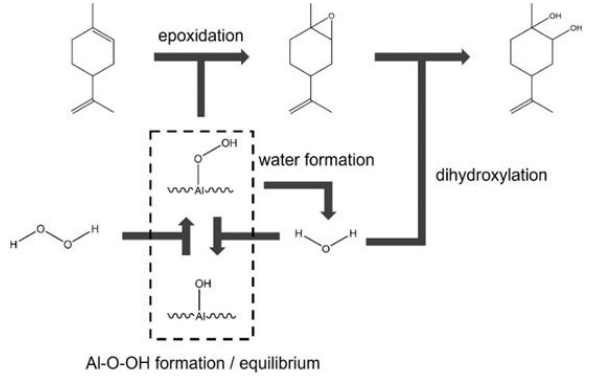

Figure 2: Interactions among water and critical components in limonene epoxidation.

Lin, H.-H., et. al. Chemical & Biological Engineering. doi: 10.1021/cbe.4c00151 (JBEI #1219)

JBEI
Joint BioEnergy Institute

Identification of Sabatier Descriptors for Hydrodeoxygenation Activity and Selectivity on Supported Molybdenum Oxide Catalysts

Background/Objective

- Deriving value from the lignin portion of biomass.
- MoO3 has been found to be effective for the HDO of lignin derivatives giving aromatics, alkenes and alkanes.
- Exploring if supporting the MoO3 phase could increase activity and alkene selectivity.

Approach

- Synthesized, characterized and tested MoO3 supported on a range of metal oxides.

Results

- Support could modify strength of key Mo=O bond with titania supports yielding highest activity.
- Alkane selectivity could be minimized using metal oxides with relatively low or high zero point charge (silica, alumina).

Significance/Impacts

- Activity and selectivity could not be simultaneously optimized, so further work is needed with mixed metal oxide supports.

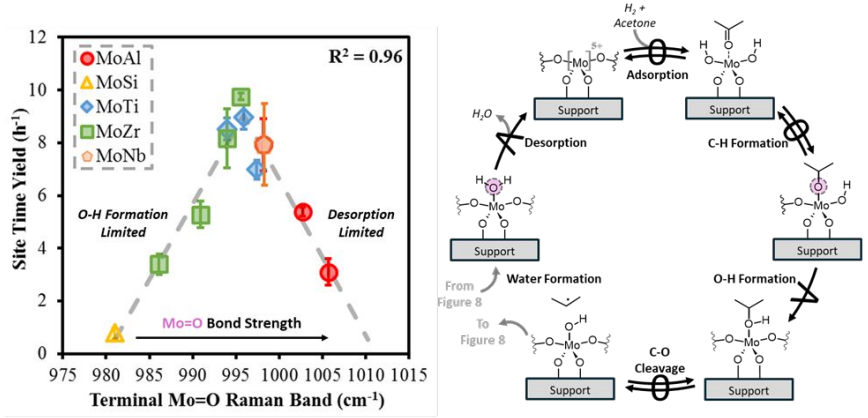

Figure 1: Observed Sabatier relationship between the site time yield (h^{-1}) of acetone HDO and the proposed kinetic effects during the reverse Mars van Krevelen mechanism.

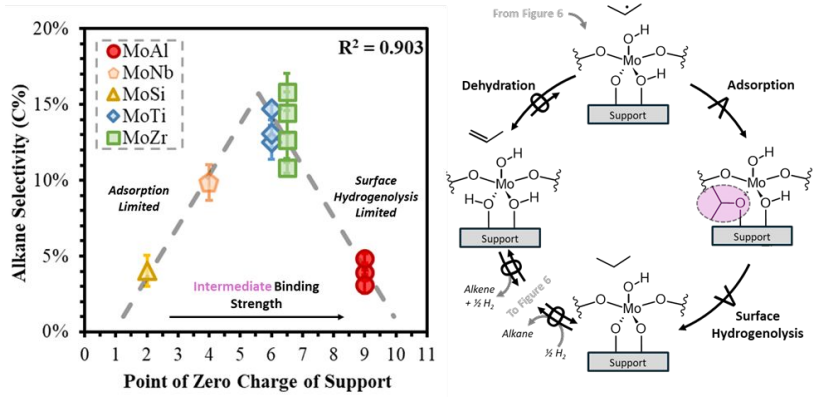

Figure 2: Apparent Sabatier volcano relationship between alkane selectivity during acetone HDO and the point of zero charge.

Kohler, A.J., et. al. ACS Catalysis. doi: 10.1021/acscatal.4c07504 (JBEI #1220)