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The algae slaughterhouse - integrated conversion of algae biomass to fuels and chemicals using biocatalyst consortia

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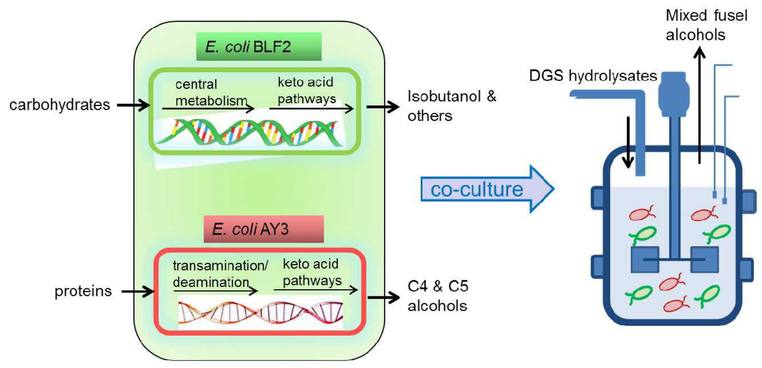
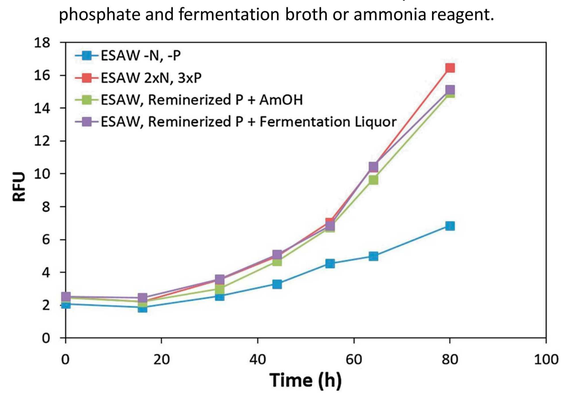
Background

A key challenge for use of algae biomass for renewable commodities is efficient utilization of all of the major biochemical fractions of the biomass, including carbohydrates, proteins, and lipids. Development of a combined algae processing biorefinery would facilitate co-production of petroleum displacing chemicals with the intermediate to high value products that are currently produced from algae. To overcome issues involved with highly variable feedstock composition, our group is developing means for single-pot bioconversion of amino acid and sugar oligomers from algae hydrolysates to generate a variety of petroleum-displacing end products. Various highlights from this work are discussed.

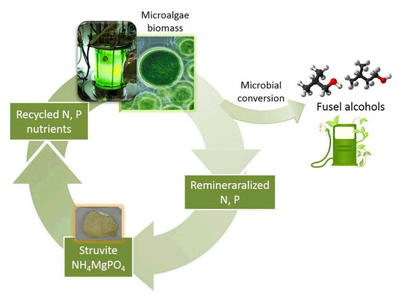


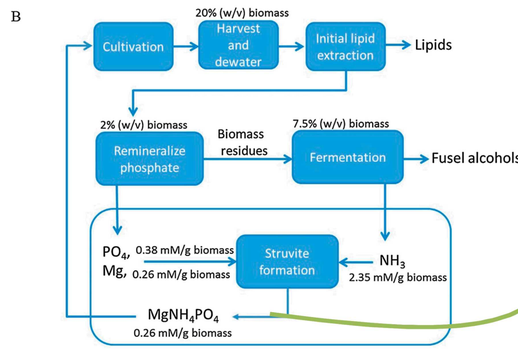
Nutrient Recycling of Algae Biomass via Struvite

Growth curves of M. salina cultures grown in the control media and the media with struvite formed by remineralized phosphate and fermentation broth or ammonia reagent.

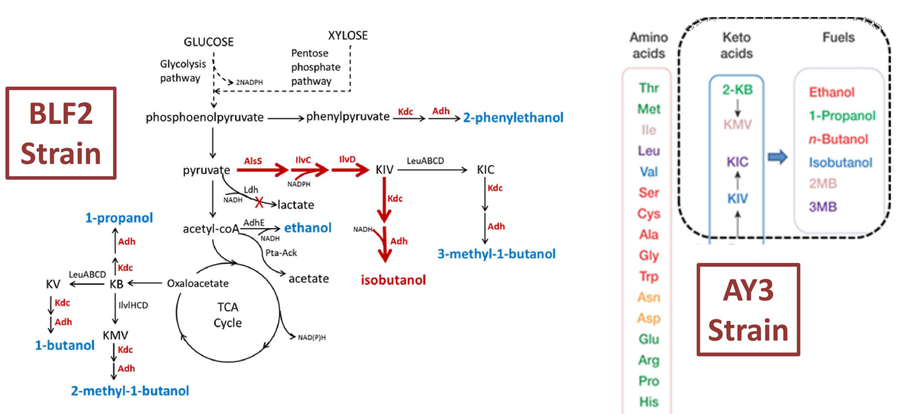


Element	% of mass (w/w) Experimental data	Predicted based on $NH_4MgPO_4 \cdot 6H_2O$
C	0.2 ± 0.1	0
H	6.1 ± 0.2	6.6
O	63 ± 1.1	65.2
N	5.1 ± 0.9	5.7
S	0	0
Mg	7.4 ± 0.3	9.9
P	14.3 ± 0.2	12.6
solid %	60.6	56.0
AFDW	26.9	13.1

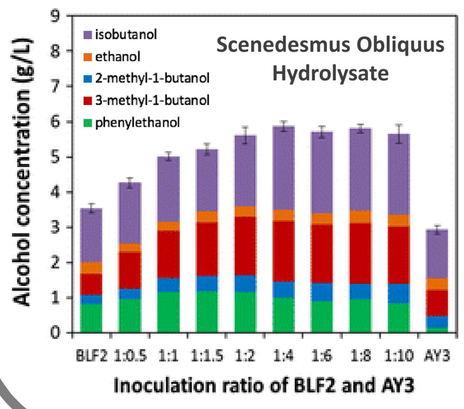




Strain Development/Optimization



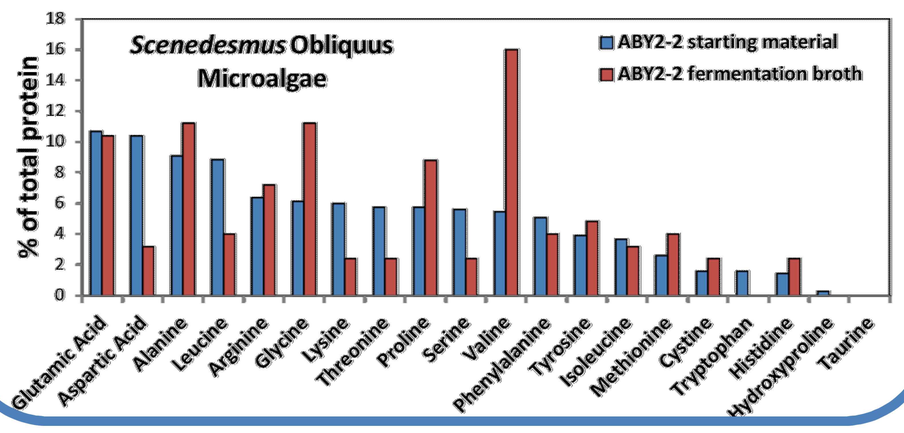
Huo et al Nat. Biotech. 2014



- Carbohydrate conversion strain **BLF2**: cloned the 2-keto acid pathway to *E. coli* ATCC 11303.
- Protein conversion strain **AY3**: engineered to deaminate proteins and able to utilize amino acids as the sole carbon source for growth.

Protein Enrichment

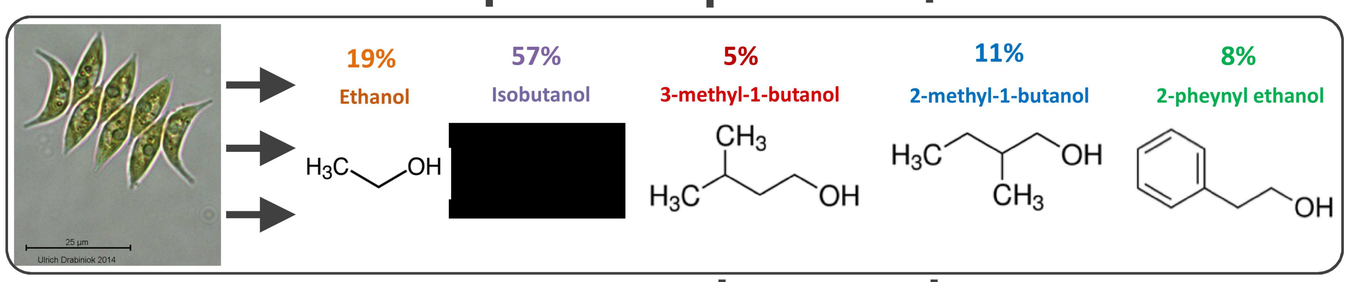
- High value AA such as Valine see a > 2X relative % increase in post fermentation broth
- Low value AA such as aspartate and leucine have their relative % dramatically reduced



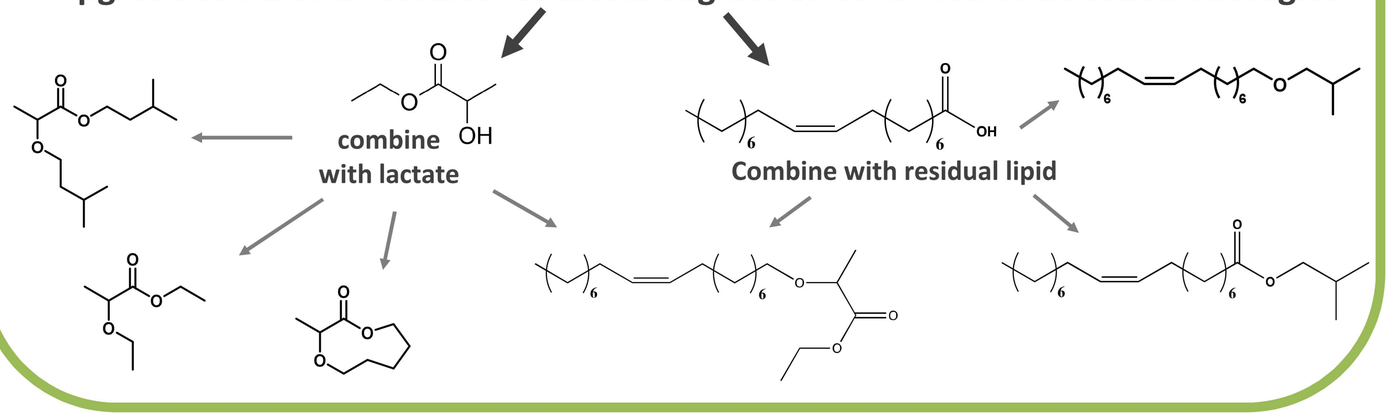
Investigation of Fusel Alcohol Blends Under the Co-Optima Initiative

Strong Performance / Good Performance / Marginal Performance / Poor Performance	Scenedesmus Fusel Alcohol Blend	Ethanol	Methanol	Isopropanol	Isobutanol	Diisobutylene	Furan Mixture	Cyclopentanone
Blending RON	127	130	143	122	109	130	146	125
Octane Sensitivity	12	19	20	12	19	19	15	12
HoV [kJ/kg]	691	919	1173	744	508	318.2	355	504
Energy Density [MJ/kg]	35.2	26.8	20.1	30.7	33.1	44.3	34	32
Sooting index	32.7	10.3	6.6	19.2	26.2	68.5	NA	22
Particulate Index	1.8	0.06	0.05	0.08	0.17	0.57	0.57	0.74
Water solubility [g/L]	-	1000	1000	1000	85	0.004	2.2	60.8
Stability/Compatability Issues	Minimal	Moderate	Extreme	Moderate	Minimal	Moderate	Extreme	Extreme
Blended Vapor Pressure	Low	High	High	High	Moderate	Low	-	-

Use directly as blending agent in gasoline – Ranked as a "Top 10 Bioblendstock"



Upgrade to other molecules for diesel engines or advanced combustion strategies



Conclusions/Future Work

- Additional strain engineering to improve yields and selectively enrich for specific amino acids
- Technoeconomic Assessments of various upgrading strategies to determine most valuable product

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