Predictive Modeling Can De-Risk Biobased Production

James Gardner, Gilbert Yang, Phil Coffman, Akash Narani, and Deepti Tanjore
Advanced Biofuels (*and Bioproducts)* Process Demonstration Unit (AB–PDU),
Lawrence Berkeley National Laboratory, Emeryville, CA

Introduction

Technologies developed to generate bio-based products are based on single feedstock types. While this approach is applicable for corn stover in the MidWest, for states such as California, with abundant but diverse feedstocks, technologies should be developed to accommodate multiple feedstock input to a single biorefinery. This project established the influence of mixing feedstocks on downstream sugar recovery and thereby fuel production for Imperial County as a case study. We relied on statistical approaches and developed a predictive model to identify optimal biomass concentrations and reaction types, temperatures, and times to maximize sugar yield and minimize furfural production.

Predictive Model generated by SAS JMP®

Feedstocks with 1-100% of
Corn Stover (CS)
Loblolly Pine (LP)
Energy Cane (EC)

Pretreatments – Categorical variable
Acid – 1% w/w H_2SO_4
Alkali – 1% w/w NaOH
Hydrothermal – Water only

Temperature – Scaled variable (1 – 100%)
Acid (Ac)– 140 to 180°C
Alkali (Al) – 55 to 120°C
Hydrothermal (Hy) – 140 to 180°C

Time – Scaled variable (1 – 100%)
Acid – 5 to 50 minutes
Alkali – 1 to 24 hours
Hydrothermal – 5 to 50 minutes

Table1: Experimental Design generated by SAS JMP®

Whole plots	PT	Temp%	°C	Time %	Min	CS	LP	EC
1	Hy	1	140	39	26	0.0	1.0	0.0
1	Ac	1	140	100	60	0.3	0.4	0.3
1	Al	1	55	100	1440	0.0	0.0	1.0
1	Al	1	55	39	589	0.0	0.5	0.5
1	Al	1	55	100	1440	0.0	1.0	0.0
1	Hy	1	140	100	60	0.0	0.0	1.0
2	Ac	100	180	1	5	0.0	0.6	0.4
2	Ac	100	180	60	38	1.0	0.0	0.0
2	Al	100	120	1	60	0.0	1.0	0.0
2	Al	100	120	1	60	1.0	0.0	0.0
2	Al	100	120	1	60	0.0	0.0	1.0
2	Hy	100	180	1	5	0.0	0.0	1.0
3	Hy	39	155	100	60	0.5	0.5	0.0
3	Ac	39	155	1	5	0.0	0.0	1.0
3	Hy	39	155	1	5	1.0	0.0	0.0
3	Al	39	80	1	60	0.3	0.4	0.3
3	Ac	39	155	1	5	0.4	0.6	0.0
3	Al	39	80	100	1440	1.0	0.0	0.0
4	Ac	80	172	80	49	0.0	1.0	0.0
4	Hy	80	172	80	49	1.0	0.0	0.0
4	Hy	80	172	80	48.8	0.0	1.0	0.0
4	Hy	80	172	1	5.0	0.5	0.0	0.5
4	Al	80	107	80	1159	0.2	0.4	0.4
4	Ac	80	172	80	48.8	0.0	0.0	1.0

Methods and Materials

Compositional Analysis of Feedstocks	NREL Laboratory Analytical Protocols
Pretreatment Reactor	15 ml SS316 tube reactor
Pretreatment Heating Medium	SBL-2D Fluidized Sandbath (Techne) or MaxQ8000 Incubator (Thermo)
Enzyme Loading	CTec2 (40 mg/ g glucan)
Enzymatic Hydrolysis Conditions	50°C and 24 hours

Pretreatment and Enzymatic Hydrolysis of Mixed Feedstocks

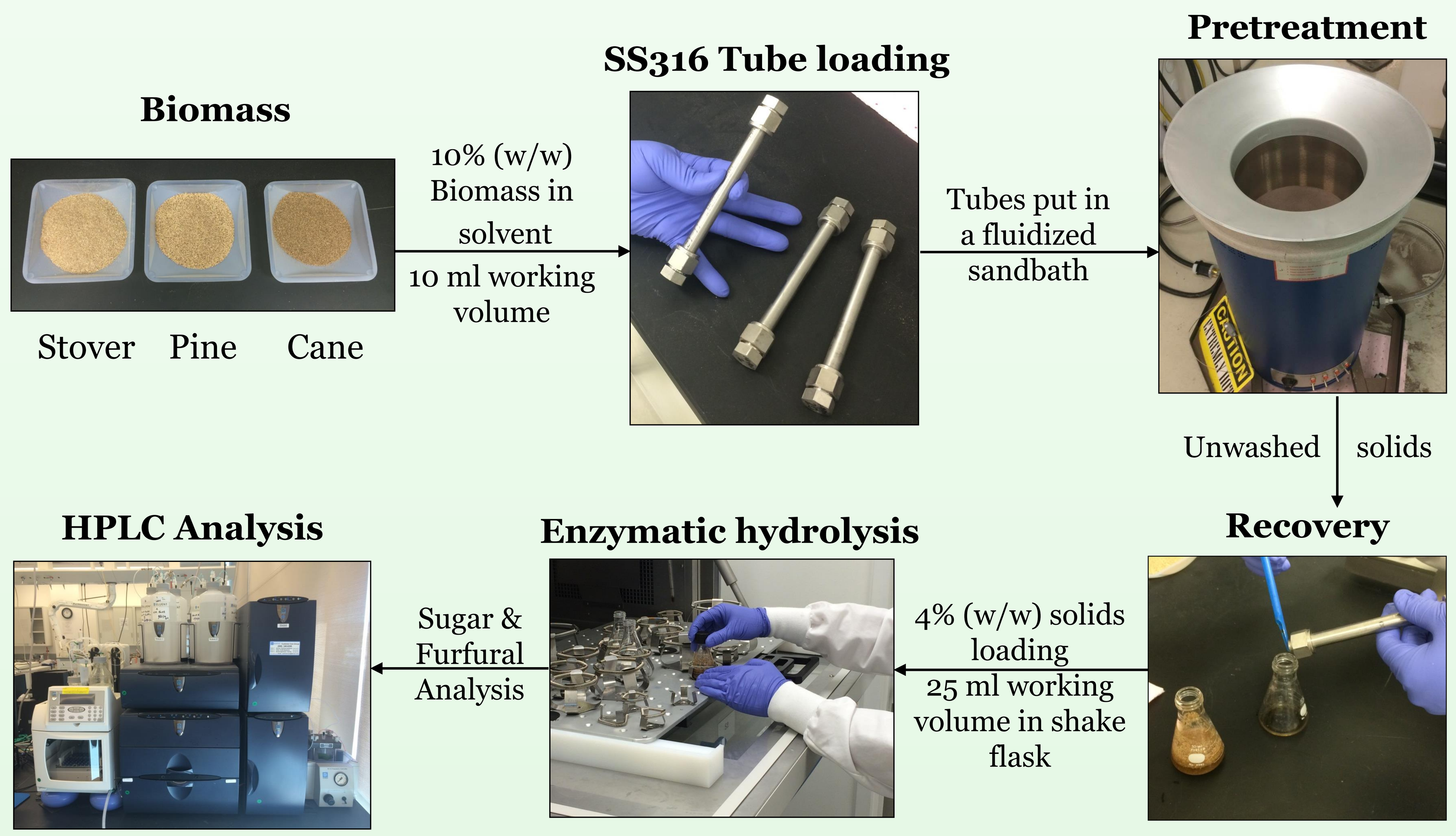
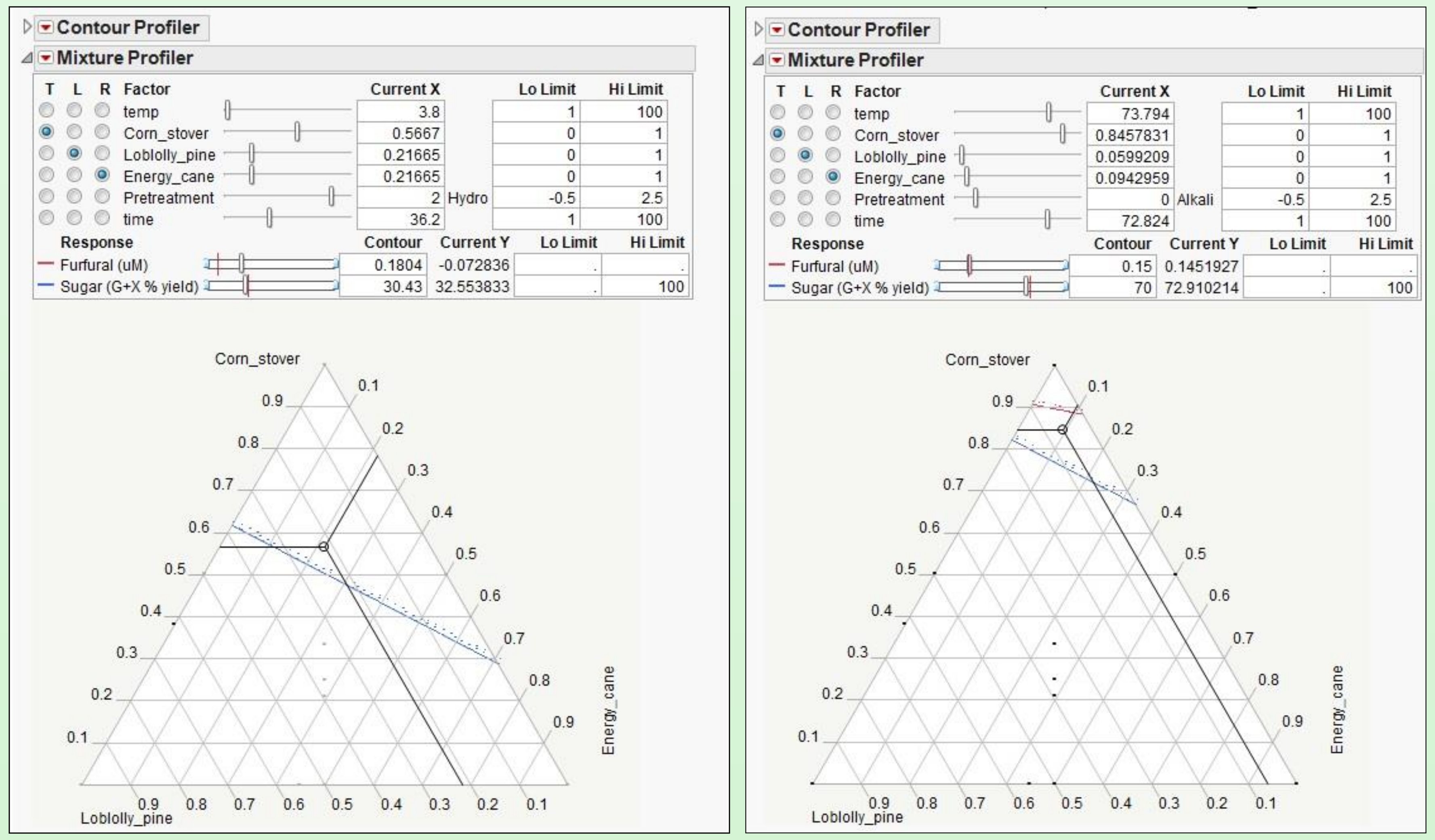


Figure 1. Pretreatment and Enzymatic Hydrolysis at Small scale for Mixed feedstocks

The Model can generate Continuous Envelope of Feedstock Mixtures



(a) 30% (b) 70%

Figure 2. A Ternary Plot of Mixed Feedstock Composition for Predetermined Sugar Yields

Alkali Pretreatment shows Highest Sugar Yields for Mixed Feedstocks

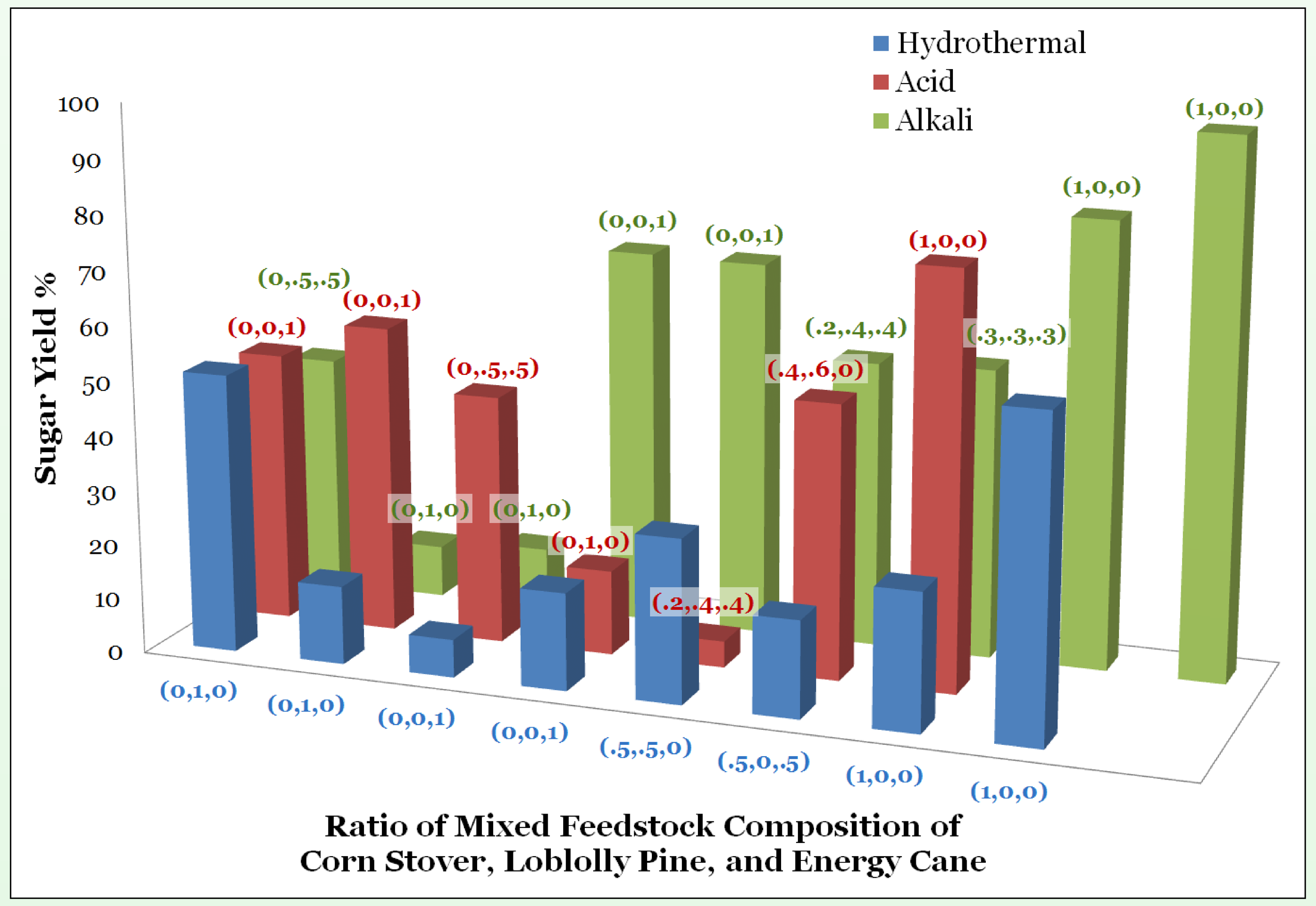


Figure 3. Sugar yields of mixed feedstocks with different pretreatments

Summary/Conclusion

- Results from the treatments were fed into the predictive model to determine several combinations of feedstocks and pretreatments to achieve more than 70% theoretical sugar yield.
- Alkali treatment was most successful in deconstructing mixed feedstocks as it led to highest sugar yields in multiple treatment conditions when compared to Acid and Hydrothermal treatments.
- Predictions made from this study will reduce the risk in establishing a biorefinery in Imperial County by reducing its dependence on one feedstock and simultaneously maintaining overall product yields.
- Predictive modeling can be applied to convert mixed feedstocks in several geographic areas for the sustenance of bio-based economy. We will continue to perform several treatments in the future with varied feedstock compositions and pretreatments to build a robust global model.

Acknowledgements

This work was funded by DOE – EERE Division, BioEnergy Technologies Office (BETO)

We would like to thank our collaborators: Kevin Kenney, Vicki Thompson, and team from Idaho National Laboratory (INL) and Terrestrial Carbon Analytics (TCA)

Contact Information

Akash Narani, M.S. Chemical Engineering
Associate Process Engineer
AB-PDU, LBNL
Email: Anarani@lbl.gov
Office :510-486-4528; Cell: 716-866-4967

BERC Energy Summit Innovation Expo, 16th October 2014, Berkeley, CA