NABC National Advanced Biofuels Consortium
Biofuels for Advancing America
Developing cost-competitive, sustainable biofuels for today's transportation infrastructure.

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CLS Proven in Stage I, Catalyst Optimization Ahead

The Catalysis of Lignocellulosic Sugars (CLS) strategy utilizes the BioForming process, Figure 1, which combines two catalytic steps, aqueous phase reforming (APR) and acid condensation (AC), to produce BioFormate. During Stage I, Virent demonstrated the BioForming process, producing a high-value hydrocarbon product similar to a reformate stream produced in a standard petroleum refinery. In alignment with the NABC objective to ensure the cost effectiveness of the biofuel technology platforms, Stage II focus for CLS will move beyond proof-of-principle to optimization. One particular area of interest is improved catalyst economics for the APR and AC steps.

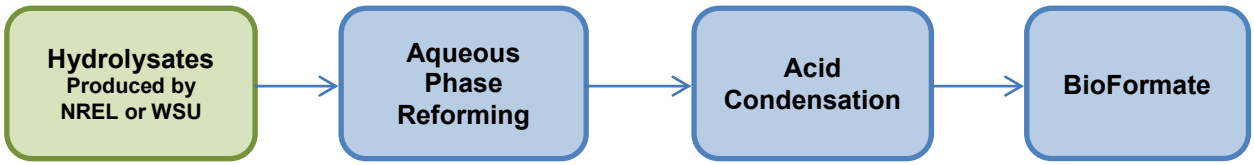

Figure 1. BioForming process

It was learned during Stage I that the investigated hydrolysate streams posed new challenges to the catalytic systems utilized by Virent's process. In Stage II, Virent will work with Pacific Northwest National Laboratory (PNNL) and Washington State University (WSU) on optimization and implementation of the second-generation APR catalyst. Similarly, Virent and Albemarle Corp. will work together to develop an improved acid condensation catalyst.

To advance the APR catalyst, PNNL will initially focus efforts on metals optimization using their Catalyst Automated Testing (CAT) Center for high-throughput screening. The CAT Center consists of a suite of automated instruments, Figure 2, controlled and monitored by a central database. It is designed to quickly test catalysts on a milligram scale. Preparation of the APR catalysts utilizes PNNL's automated incipient wetness impregnation robotics. Multi-vial batch reactors (operating up to 200°C/1,500 psig or 400°C/1,000 psig) provide rapid first stage screening, while multi-channel flow reactors (operating up to 500°C/2,000 psig) potentially allow for more in-depth second stage screening. Throughout the entire process, integrated analysis and data recovery tracks experiment results to manage data reporting. Additionally, PNNL offers several advanced analysis methods for catalyst characterization that will be utilized to study catalyst deactivation mechanisms. WSU will be working closely with PNNL and Virent, leveraging the learnings from the CAT Center work to increase the understanding of the impact of catalyst surface promoters on the reaction chemistry and ultimately catalyst deactivation mechanisms.

Likewise, Virent will work with Albemarle to enhance the zeolite-based AC catalytic system to convert APR-derived oxygenates to a non-oxygenated reformate stream. In Stage II, Virent and Albemarle will investigate the effects of steaming on these zeolitic materials. In addition to providing materials for testing within the BioForming process, Albemarle will conduct characterization studies of spent catalyst

to help determine catalyst deactivation mechanisms. Additionally, Albemarle will be providing commercial catalyst costing information for the AC catalyst that will be utilized for the process techno-economic analysis (TEA).

By leveraging the strengths of the three partners – PNNL, WSU, and Albemarle – Virent will be able to improve the process economics for the BioFormate fuel product and ultimately demonstrate 1,000 hours of continuous operation utilizing lignocellulosic feedstocks, advancing the CLS strategy one step further toward commercialization and increasing the economic advantage for the BioFormate product.

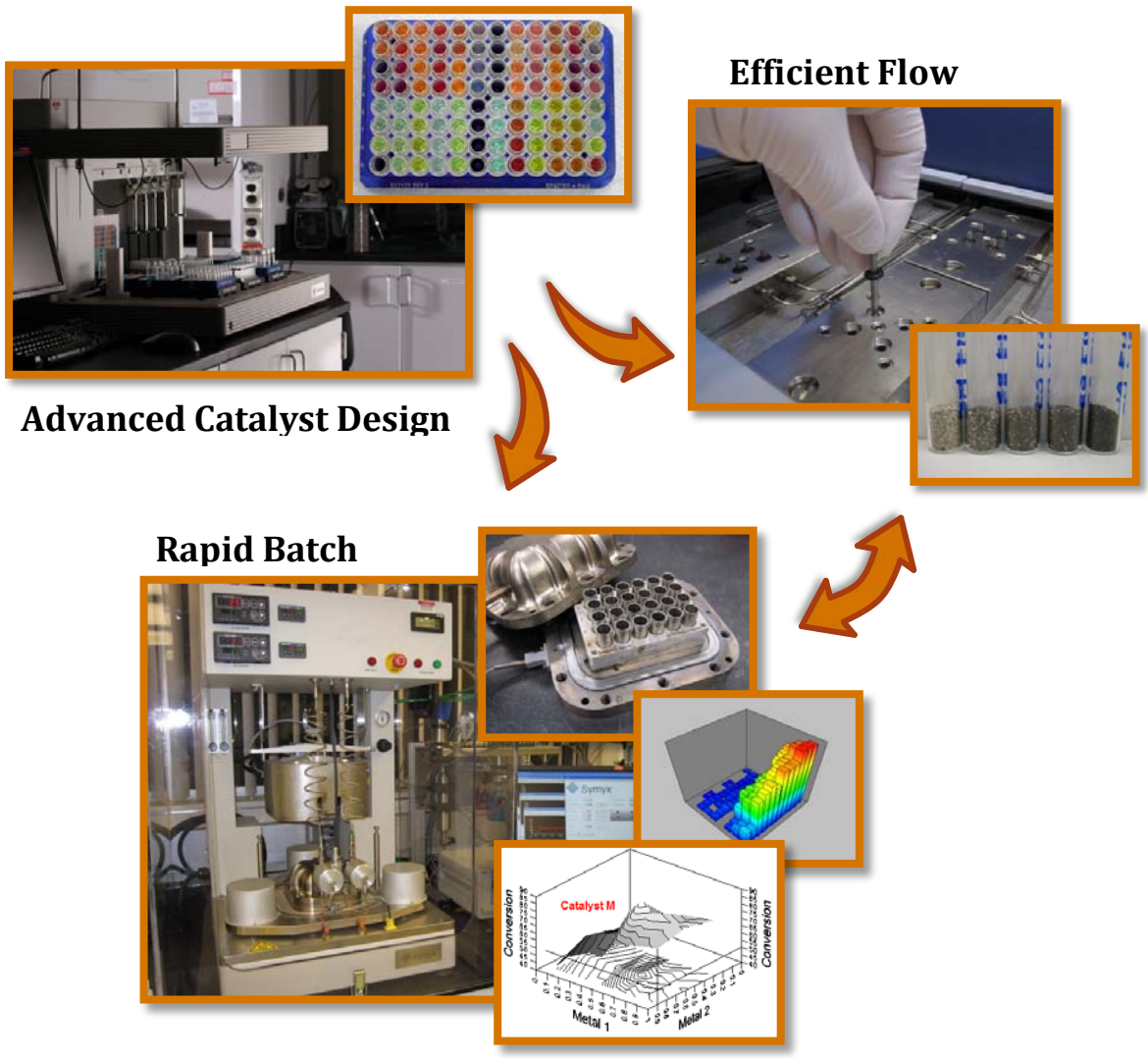

Figure 2. The CAT advantage: novel catalyst compositions are designed and prepared using the Advance Catalyst Preparation laboratory located at PNNL. The catalysts are rapidly tested at temperature and pressure in the multi-vial batch reactors. Additional testing and optimization can then be conducted in the 16-channel flow reactor. The capability was funded by DOE's Office of the Biomass Program and is being used to support catalyst development efforts in NABC.