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

January 1, 2013

Hydrolysate Conditioning in the Catalysis of Lignocellulosic Sugars Strategy

Within the Catalysis of Lignocellulosic Sugars (CLS) strategy of the NABC, Virent uses hydrolysates produced by the National Renewable Energy Laboratory (NREL) and Washington State University (WSU) to generate a gasoline-range biofuel with high aromatic content. These hydrolysates contain sugars derived from cellulose and hemicellulose, sugar and lignin degradation products, and other deconstruction products such as organic acids (Figure 1), all of which can be converted through Virent's unique BioForming® process. The hydrolysates also include chemicals used in the deconstruction process, ash from the biomass, and other unreacted or recondensed biomass components (Figure 2). Insoluble solids from unreacted or recondensed biomass components should be removed prior to conversion in the BioForming process because they can produce a high pressure drop when run through a fixed bed catalyst system. Proteins and inorganic compounds in hydrolysates are problematic for catalytic processing, as they impact materials of construction (e.g., chloride and fluoride), accumulate in heat exchangers (e.g., silica) and contribute to catalyst poisoning (e.g., sulfur). To counteract these effects, Virent has developed a hydrolysate conditioning process to separate, purify, and concentrate the soluble deconstruction products. These processing steps improve the efficiency of the catalytic process and result in a high-quality biofuel product.

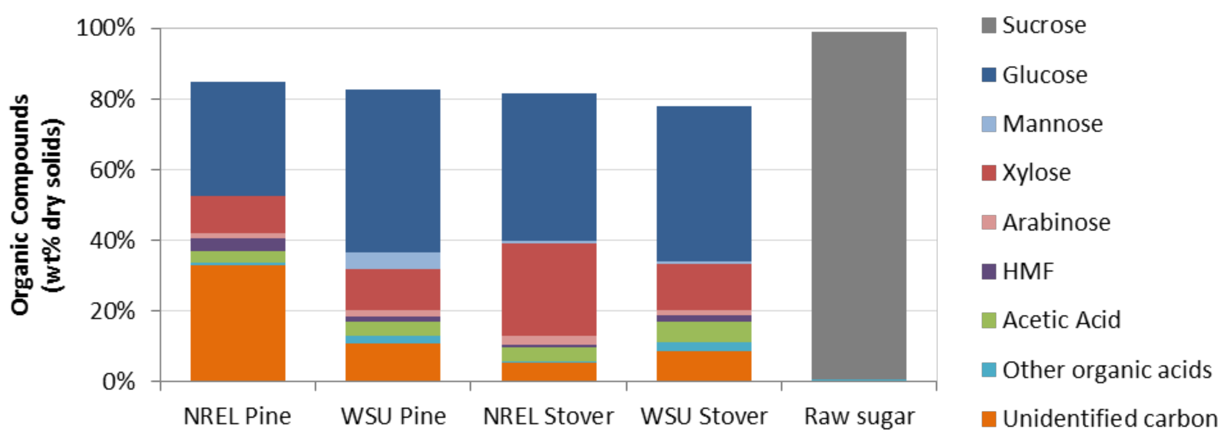

Figure 1. Average sugars and other identified organic compounds in NABC hydrolysates and raw cane sugar

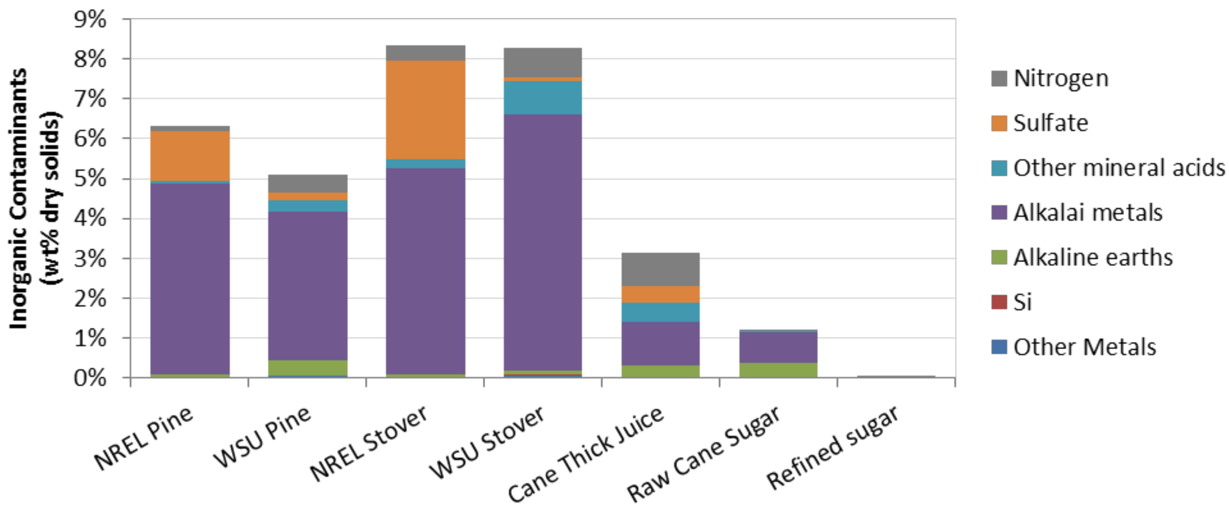

Figure 2. Average nitrogen and inorganic compounds in NABC hydrolysates and conventional sugar streams

Solids removal

The hydrolysate slurries produced by NREL and WSU contain as much as 30% insoluble solids by volume. For solid-liquid separation via filtration, particle size distribution is a key indicator in filtration performance. These hydrolysate slurries have a very broad particle size distribution, ranging from approximately 0.1 micron to greater than 1 mm. To assist with the processing of these slurries, Pall Corp is developing a crossflow filtration apparatus that can process the high-solids slurries more efficiently and cost effectively than the dead-end filtration or centrifugation that has been practiced to date within the NABC.

Contaminant removal

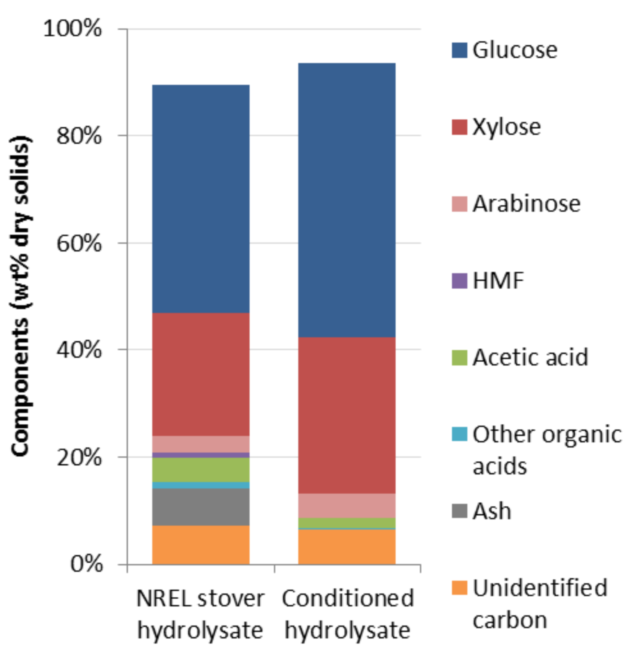

Figure 3. Effectiveness of contaminant removal

Removal of contaminants can be achieved using various known techniques. For instance, ion exchange technology is commonly used in mature industries, such as sugar refining, to remove impurities from product streams. This technology is adaptable to hydrolysate purification. As part of this process, hydrolysate feed is passed over a series of resins to remove contaminants and achieve the target feed purity.

The purified product contains lignocellulosic sugars and other organic components that are not absorbed by the resin (Figure 3). Key contaminants of concern for materials of construction and catalyst stability are effectively removed; however, small amounts of other undesirable components are maintained in the purified hydrolysate product. Alternative methods to remove these compounds continue to be researched.

Although ion exchange has worked well to purify laboratory-scale volumes of hydrolysate, high levels of contaminants necessitate frequent resin regeneration, which can become cost prohibitive. As a result, Virent is evaluating other industrial solutions for purification of high ash streams to reduce the economic impact of the purification step.

Water removal

Biomass hydrolysates are typically in the range of 10–15 wt% sugar and may be diluted further in the conditioning process. These high water concentrations increase the heat demand and require larger process equipment to accommodate the non-reactive water in the feed. Because of this, the hydrolysate streams are dewatered prior to introduction to the BioForming process. Following common industrial practices, a vacuum evaporator is used to minimize sugar degradation. During this process, a small amount of highly volatile deconstruction products are removed with the water, but the bulk of the deconstruction material and all of the sugars are retained in the concentrated hydrolysate syrup.

Summary

Commercial technologies have been adapted to our processes for the conditioning of biomass hydrolysates prior to catalytic conversion of sugars. Ongoing work in this area is focused on technologies with projected lower costs at commercial scale than centrifugation and ion exchange. Conditioning is a vital prerequisite for catalyst operability, and final specifications will depend on the reactor configuration and type of catalyst used in BioForming.