The role of supercritical hydrolysis

The success of the global biochemical and fuels market – estimated to exceed $1 trillion (€800 billion) by 2025 – hinges on the accessibility of affordable, reliable supplies of feedstocks such as sugar. As petroleum becomes more difficult to access, driving up production costs, manufacturers are seeking affordable sugars as an alternative to meet increased demand for everyday products ranging from paints, plastics, food preservatives, to ethanol and petrol.

Today most available sugars are produced from food-based crops such as sugarcane, corn or beets. Brazilian sugarcane is the closest source to providing industrial sugars economically at scale, but even Brazil does not have adequate supply for its own domestic ethanol needs. Add to that global population growth, competing food markets, seasonal crop variations and limited regions of production, and it creates a marketplace vulnerable to price volatility and diminishing supplies – similar to today's petroleum market.

Large-scale bioindustrial growth at a sustainable level requires a shift to cellulosic sugars, or sugars derived from non-food plant matter; everything from woody biomass, to agriculture residues to energy grasses, even post-consumer waste available in urban areas worldwide.

Unlocking cellulosic sugar

There are three routes to cellulosic sugar production in use today. Traditional methods-enzymatic hydrolysis and acid hydrolysis—have been in development over the past few decades. However, these methods incur high costs due to either enzyme procurement or elaborate acid recovery systems, and lengthy process cycles limit the ability of these technologies to scale and compete with first generation, food-based sugar sources.

The third method, supercritical hydrolysis, uses supercritical waterwater at elevated pressures and temperatures to deconstruct biomass in a matter of seconds. Water becomes supercritical at around 374°C and 221bar. Under these conditions, distinct liquid and gas phases do not coexist. The water behaves as both a gas and a liquid, serving as a powerful solvent.

Supercritical water has chiefly been used in nuclear applications, such as heat transfer and integration, and has only recently been proven to economically produce sugar from biomass by Renmatix, a US-based company backed by German chemical company BASF.

How it works

Renmatix's two-step Plantrose process deconstructs a range of non-food-based feedstocks in a continuous reaction, producing separate steams of C5 (xylose) and C6 (glucose) sugar. Lignin is produced as a by-product.

Step one – hemi-hydrolysis: First, the biomass and water are pumped together in a slurry, primarily composed of hemicellulose, cellulose and lignin. The slurry is heated and pumped to moderate

conditions and fed to the fractionation reactor, where the hemicellulose is solubilised into a C5 sugar stream. The cellulose and lignin remain as solid particles and are carried on to step two.

Step two — supercritical hydrolysis: The collected solids are mixed with water to form a new slurry and pumped into the supercritical hydrolysis reactor. At this stage, elevated heat and more intense pressure conditions are used to deconstruct the cellulose into a C6 sugar stream in a rapid reaction. The only remaining solid is lignin, which can be used to fuel the process' thermal energy needs.

Advantages

Supercritical hydrolysis offers significant advantages in both speed and cost over traditional methods of cellulose hydrolysis. Using enzymes or harsh acids in a batch process can take hours/days to yield sugars, and requires elaborate processing and recovery equipment. This is in addition to the added expense of the enzymes or acid itself.

Renmatix's approach uses locally available tap water with little or no pretreatment. More than half of the biomass feedstock coming in is water content. This water and additional water resources are managed sustainably and reused throughout the process. The majority of the equipment needed is standard industrial equipment and the rapid reaction cycles enable the use of small reactors. Smaller equipment lends itself to modular, capital efficient production facilities based on sustainable, cost-effective feedstock sources.

Scaling

Renmatix engineered and scaled its supercritical hydrolysis technology using woody biomass. In the past four years, the company scaled the Plantrose process dramatically, expanding from its 100kg per day pilot line to a demonstration facility capable of converting three dry tonnes of woody biomass to sugar per day.

These sugars have been tested and proven compatible by downstream chemical and fuel producers, who apply their own conversion technologies, either catalytic or biological, to create a range of biochemicals and fuels. Industry momentum is building for applications of cellulosic sugar that would lead to isobutanol, lactic acid, polypropylene, polyethylene, ethanol, N-butanol and diesel, among others. Renmatix is working diligently to be in a position to enable the emergence of these bio-based materials at scale.

Building on this success

Feedstock flexibility is a core advantage of supercritical hydrolysis. By slightly altering reactor conditions, Renmatix can scale Plantrose to support a variety of plant material and waste streams.

In addition to researching hardwoods in multiple global markets, the company is examining more than 50 sustainable biomass sources available in North America, South America, Asia and Europe.

In August, Renmatix entered a joint development agreement with Waste Management, the largest waste management provider in North America, to investigate the potential of converting post-consumer municipal solid waste into low-cost, sufficient quality sugars. Tapping into the post-consumer waste steam could unlock a world of opportunity for bioprocessing in large urban areas that lack abundant and sustainable biomass, but with an increasing supply of waste material.

For more information:

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