BIOMASS TO TRANSFORM THE CHEMICAL INDUSTRY

BY GUNNAR LIDÉN, PROFESSOR OF CHEMICAL ENGINEERING, LUND UNIVERSITY, SWEDEN

The advances that have been made in metabolic engineering of various host organisms today enables a growing number of chemical compounds to be produced from sugars, rather than petroleum. Some of these products, such as propanediol, and lactic and succinic acid, are reaching commercial-scale production.

Widening the raw material base for industrial biotechnology from only pure sugars to include also the use of various sources of biomass is essential for many different reasons, including decreasing the climate change impact from our chemical industry, and minimising the direct competition between sugars for food use and other industrial uses.

This ongoing transition started in the fuel ethanol business with commercial-scale installations by companies like Du Pont and POET-DSM in Iowa, and GranBio and Raízen in Brazil.

Biomass, such as agricultural by-products like wheat or rice straw, as well as forestry by-products, contain 'sugars' in the form of polymeric carbohydrates, as well as other compounds—most importantly lignin. The polymeric carbohydrates are not directly amenable to biological conversion, but nature has developed enzyme systems able to hydrolyse and degrade the polymeric carbohydrates to simple sugars.

The degradation of the polymers in native biomass is by ecological necessity a very slow process—with a time scale of months—and does not meet the demands of commercial biotechnological production. For this reason, an initial thermal, chemical and/or mechanical processing of biomass—often called 'pretreatment'—is necessary to speed up the enzymatic hydrolysis.

An obvious and fundamental problem when using biomass as a raw material is that it is a solid, which, furthermore, in contrast to pure sugars, is not water soluble. Getting the biomass converted into a processable slurry is a necessary first step, which is accomplished in pretreatment. The pretreated slurries obtained typically have unfavourable rheological properties, such as high viscosities and exhibiting yield stress. Dilution of the slurries to decrease viscosity is not an option, since downstream costs would in such case increase, but further processing by enzymatic hydrolysis in most cases lowers the viscosities and gradually makes the carbohydrates water soluble as hydrolysis proceeds.

At Chemical Engineering, Lund University, Sweden, research on lignocellulose processing, including pretreatment and enzymatic hydrolysis, is a core theme. Vast experience in pretreatment of many different materials has been obtained through more

A continuous steam pre-treatment unit at Chemical Engineering, Lund University

than 25 years of operation of a process demonstration unit. Significant differences in the liquefaction behaviour of agricultural residues and softwood have been found.

> Several industries will benefit from a better processing knowledge regarding biomass. The renewal of the chemical industry will likely take place in a synergy between biotech companies—providing the key technology in terms of new production strains and enzymes—and the traditional chemical industries...

Recently, we have investigated the interaction between mixing conditions and hydrolysis during the enzymatic hydrolysis, and found some a priori unexpected differences. The take-home message is that to find the solution to getting the biomass into solution, you really need to know your material!

Several industries will benefit from a better processing knowledge regarding biomass. The renewal of the chemical industry will likely take place in a synergy between biotech companies—providing the key technology in terms of new production strains and enzymes—and the traditional chemical industries that will have to learn efficient processing of biomass in addition to their classical petroleum processing.

The environmental impacts are the main long-term drivers for this technology. In the short term, there are currently no direct economic incentives to replace petrochemical feedstocks with biomass, except in certain niche markets with highly aware customers who demand sustainable production.

In some markets, however—like Europe—it is likely that incentives, taxes or regulations (such as blend mandates) will create a real drive for the development. There is, for example, a current discussion on the use of non-degradable plastics in Europe, where France has put a ban on certain plastic bags in supermarkets.

This illustrates that combining bio-based and biodegradable properties is likely to be of growing importance in the production of plastics. With a changed raw material base, a new market opens up for agriculture and forestry. We may therefore see a closer connection between the chemical industry and the agricultural/forestry sector than previously.

The transformation of the chemical industry will be larger than we can currently imagine.

Gunnar Lidén will be speaking at the 17th International Biotechnology Symposium (IBS 2016).

Wheat straw (left) and batch steam pretreated wheat straw (right)