

BIOFOREVER Article



In September 2016 a consortium of 14 European companies started the BIOFOREVER project (www.bioforever.eu) in order to demonstrate the commercial viability of a number of value chains from woody biomass to value adding chemical building blocks.

Since then the focus has been on providing wood samples (spruce, poplar and A-wood) to the 4 technology partners in order to optimize the sugar quality output a.o. from their pretreatment technology. One of the technologies used is Borregaard's BALI™ technology.

Martin Lersch from Borregaard: *"The experimental work that led to the BALI™ process began in 2007. Eventually there was a need to scale up the process in order to continue with development. Construction of the BALI™ demonstration plant commenced in 2012 and was inaugurated in 2013. The demo plant was built specifically for the BALI™ process with a capacity to process 1-2 MT/day of feedstock. The feedstocks tested so far in the demo plant include Norway spruce (*Picea abies*), loblolly pine (*Pinus taeda*), bagasse (*Saccharum spp.*) and willow (*Salix spp.*). More than 800 MT of feedstock (wet basis) have been subjected to sulfite pretreatment and downstream processing. Additionally, more than 25 MT of spruce pulp (dry basis) have been subjected to enzymatic hydrolysis. From the perspective of a "technology readiness level", the successful scale-up from lab by a factor of 1000 and several years of operation in a semi-commercial scale suggests that the BALI™ technology is at TRL (Technology Readiness Level) 6-7."*

The BALI™ process in a nutshell

Compared to Borregaard's traditional sulfite mill, the BALI™ process produces only two products - lignin and sugar - instead of four (cellulose specialty pulp, lignin performance chemicals, vanillin and bioethanol).

Woody feedstock is subjected to a sulfite pretreatment which renders the lignin water soluble. This is a unique feature of the BALI™ process as it allows easy separation of the lignin from the cellulose fraction early in the process.



BALI™ Demo Plant, Sarpsborg Norway

Pretreatment of the feedstock, separation of lignin from pulp, washing of pulp, lignin processing and enzymatic hydrolysis are all performed in the main machine hall.

After washing of the pulp, cellulase enzymes are added in order to hydrolyze the pulp. After separation of any residual unhydrolyzed particles the hydrolysate is either used as is, or subjected to evaporation for concentration. The BALI™ hydrolysates are known as **BALI™ drop-in sugars** and are characterized by a high purity and very low concentrations of inhibitors, making them an ideal starting point for fermentations or chemical conversion to chemicals and building blocks. They can be blended with conventional 1G dextrose syrups (e.g. DE95 syrups) at any ratio and ultimately replace these, without loss of fermentation activity. The crude lignin stream may contain sugar if the pretreatment has been performed under acid conditions. These may then be fermented prior to further downstream processing of the lignin to lignin performance chemicals.



Following the enzymatic hydrolysis the resulting hydrolysates can be fermented in 30, 300 and 3000 L reactors in a state of the art multi-purpose fermentation facility located right next door to the BALI™ demo plant

Martin Lersch: *“Borregaard only intends to commercialize the BALI™ technology when further dependable and sustainable supply of lignin raw material is required.”*



During more than 125 years of pulping operations Borregaard has transitioned from a traditional pulp and paper company to a fully integrated biorefinery positioned within lignin performance chemicals, speciality cellulose, wood based vanillin and 2G bioethanol produced from spruce. Core to the biorefinery concept is a high degree of raw material utilization, made possible with strong RD&I efforts and a favorable mix of low and high value products. In its sulfite mill in Sarpsborg, Norway, Borregaard produces four major products: cellulose specialty pulp, micro fibrillated cellulose, lignin performance chemicals, vanillin ex-lignin and cellulosic bioethanol. In addition to this (the Norwegian operation) Borregaard LignoTech sources lignin raw materials from a number of external sources around the world and process same into lignin performance chemicals.

Development of the BALI™ technology would not have been possible at the present speed and extent without substantial support from the Research Council of Norway, Innovation Norway, FP7 and Horizon2020.

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