Building a sustainable European biofuel industry Gothenburg 4-6 November 2019



POTENTIALS FOR BIOCHEMICALS AND BIOMATERIAL PRODUCTS IN A SUGAR BIOREFINERY SETTING

Gudbrand Rødsrud Technology Director Business Development Borregaard AS



How are cellulosic ethanol projects doing?

Company	Project	Country	Output Capacity (ktons)	Status	Start-Up Year
Abengoa Bioenergy Biomass of Kansas, LLC	Commercial (acquired by Synata Bio Inc. [21])	US	75	idle	2014
Aemetis	Aemetis Commercial	US	35	planned	2019
Beta Renewables (acquired by Versalis [22])	Alpha	US	60	on hold	2018
Beta Renewables (acquired by Versalis)	Energochemica	EU (Slovakia)	55	on hold	2017
Beta Renewables (acquired by Versalis)	Fujiang Bioproject	China	90	on hold	2018
Beta Renewables ¹ (acquired by Versalis)	IBP-Italian Bio Fuel	EU (Italy)	40	idle	2013
Borregaard Industries AS	ChemCell Ethanol	Norway	16	operational	1938
Clariant	Clariant Romania	EU (Romania)	50	under construction	2020
COFCO Zhaodong Co.	COFCO Commercial	China	50	planned	2018
DuPont	Commercial facility Iowa (acquired by VERBIO [23])	US	83	idle	2016
Enviral	Clariant Slovakia	EU (Slovakia)	50	planned	2021
Fiberight LLC	Commercial Plant	US	18	under construction	2019
GranBio	Bioflex 1	Brazil	65	operational	2014
Henan Tianguan Group	Henan 2	China	30	Idle	2011
Ineos Bio	Indian River County Facility (acquired by Alliance Bio-Products in 2016 [24])	US	24	idle	NA
Longlive Bio-technology Co. Ltd.	Longlive	China	60	Idle	2012
Maabjerg Energy Concept Consortium	Flagship integrated biorefinery	EU (Denmark)	50	on hold	2018
POET-DSM Advanced Biofuels	Project Liberty	US	75	operational	2014
Raízen Energia	Brazil	Brazil	36	operational	2015
St1 Biofuels Oy in cooperation with North European Bio Tech Oy	Cellunolix®	EU (Finland)	40	planned	2020

¹ Joint venture of Mossi & Ghisolfi Chemtex division with TPG.





Turning all parts of the wood log into products

The "LIGNIN COMPANY" Leading supplier of lignin based performance chemicals

Top 3 supplier of high quality specialty cellulose

Only supplier of vanillin from wood

Only supplier of MFC

The largest producer of ethanol from wood



Borregaard company

1050 employees

500 M€ annual sales

Production in **7 countries**

Sales offices in **16 countries**





What is BALI™? (Borregaard Advanced Lignin)

- BALI[™] is a patented biorefinery concept developed by Borregaard for c0-production of cellulosic sugars and lignin performance chemicals
- BALI[™] is a true lignin first technology
- The BALI[™] technology has been scaled up and demonstrated in a 1 mt/day demo plant since 2013.
- The technology is ready for full scale investments when the timing is right





Excello range of cellulosic sugars

3 grades of cellulose hydrolysates from the BALI[™] technology has been developed.

Excello range of cellulosic sugars is produced in parallel with lignin performance chemicals.

Excello sugars has shown an outstanding fermentation performance.

	Excello 90	Excello 95	Excello 99			
Typical use	Lignocellulosic drop-in replacement for starch based sugar					
Drop in for	DE95	Refined DE95 syrup				
Total sugar (% of DM)	90%	95%	>99%			
C6 of total sugar	90-95%					
Fermentation inhibitors	Insignificant					

C Excello





For more information about Excello and samples, please contact Martin Lersch, CTO Business Development at martin.lersch@borregaard.com

Exilva - Microfibrillated cellulose (MFC)

10 µm

Human hair Typical diameter 75μm (20 – 200 μm) Typical length 2 – 50 cm (20 000 – 500 000 μm)

10 µm

Cellulose fiber in paper Typical diameter 20 – 60 μm Typical length 2-3 mm (2000 – 3000 μm

10 µm

Microfibrillated cellulose (MFC) Typical diameter 10 – 100 nm (0,01 – 0,1 μm) Typical length 2 – 3 mm (2000 – 3000 μm)



Exilva - A new innovation from Borregaard

- Adhesives
- Coatings
- Agchem
- Construction
- Home care
- Personal care
- Corrugated packaging
 - Improve speed 14%
 - Improve quality (warp) 11%
 - Reduce/remove boron

Free samples https://www.exilva.com/

- Crystalline hydrophilic micro-fibrils in a nettwork
- Aquous suspension
- Gel forming
- Shear thinning
- Rheology modifiers
- Film forming

Exilva 2% dispersion

Exilva 10% paste





SenseFi (E460) defibrillated cellulose for food

Potetsalai







- Low fat products with the right mouth feel
- Multifunctional dietary fiber
- Advanced texturizing system
- Superior water binder & fat replacer healthy products
- Thickening, stabilizing and suspension
- Succulent texture and clean taste





sense i')







Asphalt recirculation on site with lignin based binder

On site milling



Crushing and blending of asphalt and bio-binder, compacting



No landfill of used asphalt, no transportation



Lower costs Reduced use of fossil apshalt Reduced environmental footprint



The method was developed by Crusher International AS (www.crusher.no)

Will aromatics from lignin be the future?

 No technological solution yet for breaking down lignin to aromatic monomers with acceptable yields



- Aromatic bonds are strong (518-636 kJ/mol)
- Aliphatic and ether bonds in lignin are weaker (255-390 kJ/mol)
- 5'-5 bonds are semi strong (490 kJ/mol)
- Thus, it should be possible to only break the aliphatic bonds without destroying the aromatic ring.
 - We may have to accept some dimers



V. MOLINARI, C. GIORDANO, M. ANTONIETTI, D. ESPOSITO, *J. AM. CHEM.* SOC. 2014, 5, 1758.

Bio-carbon must be used where there are no other sustainable alternative

CHEMICALS TRANSPORTATION LONG DISTANCE TRANSPORT

There are no alternatives to carbon in materials, chemicals and heavy transport short term







TRANSPORTATION FUEL SMALL & MEDIUM SIZED VEHICLES

MATERIALS

FUEL

AVIATION

STATIONARY ENERGY

Wind Solar Hydro Geothermal

.

are sustainable

alternatives to bioenergy

nsulated H







Biofuel ONLY projects?

SIRLOIN **Filet of the** biomass CHUCK AND BLADE 10 THICK RIB RIB CL00 **Other biomass** BRISKET components SHIT Still we do not hesitate when there Who would dream of making are plans to make biofuels from sausages of the filet and biomass with less than 50% yield dogfood of the rest of the animal? and burn the rest of the feedstock



Biofuel ONLY projects?

NO. Only in combination with higher value products in a biorefinery setting Do you hear me? ret of the biomass

Other biomass components

We do not hesitate when there is plans to make biofuels from biomass with less than 50% yield and burn the rest of the feedstock

Borregaard