Producing Bio-Based Drop-In Chemicals

2 routes competing on:
- Technology
- Costs
- Life Cycle

Chemical Intermediates
Transforming the Biomass into an Intermediate

Theoretically!

Fractions

Chemical Intermediate
Transforming the Biomass into an Intermediate

In reality!

Fractions

Furfural, HMF, Organic acids

Chemical Intermediate

Feed mat., side products, biomass,...
What is needed industrially!

- Furfural, HMF, Organic acids, Salts
- Feed material
- Side products
- Salts
- Proteins
- Biomass
Which technologies for purification?

Combining the right technologies into a complete process is the key to be competitive.

Only Advanced Purification Technologies can do the job!

Traditional Chemical Industry Technologies are not relevant!

New raw materials
New production routes
Mixtures / broths

C5 Sugars

C6 Sugars

Organic acids

Di-alcohols
We develop processes and market equipment to solve purification challenges by using advanced technologies.
Our Markets

Biopharma

- Recombinant Proteins
- Vaccines
- mAbs - ADC
- Blood Fractionation
- Biomass Extracts
- Cell Therapy

Food Ingredients

- Sugar
- Starch
- Milk

Functional Ingredients

- Polyphenols
- Anthocyanes
- FOS
- Sweeteners

Bio-Industries

- Bio Based Chemicals
  - Organic Acids
  - Aminoacids
  - Antibiotics
  - Vitamins
Facts and Figures

Novasep Process Sales: 120 M€
Employees: 430

- **Process Development**
  - # 20 purification processes per year in Industrial Biotechnology
  - # 30 purification processes per year in Biopharma

- **Equipment and Systems**
  - More than 2,000 units installed worldwide

- **Design and Engineering Offices**
  - Shanghai, Philadelphia, Lyon and Nancy

**Sales by Segment**

- Industrial Biotech: 50%
- Pharma: 10%
- Biopharma: 40%
An Unparalleled Breadth of Key Unit Operations

Biobased Chemicals Purification

Continuous chromatography
- Applexion® SSMB
- Separation of fractions
- Purification

Membrane filtration
- Organic & Ceramic
- Clarification
- Concentration

Evap/Crystallization
- Plate or tubular
- Multiple effect
- MVR

Adsorption/IEX
- Salt conversion
- Demineralization
- Decolorization
- Batch or Continuous

Electrodialysis
- Demineralization
- Salt Conversion

Purity
Working principles

Membranes + Chromatography + IEX + Electrodialysis

Efficient, cost-effective, reliable and scalable technologies
Allowing to reach high degrees of purity
& relying on the use of various physico-chemical properties:

- pKa
- Molar mass
- Hydrogen bounds
- Solvation size
- Isoelectric point
- Hydrophobic/hydrophilic interactions
- Polar/non polar interactions
- Molecular Geometry configuration
Field of application

Novasep Process designs **optimized** and **integrated** process routes

by selecting among competitive technologies depending on local conditions

to build up processes that are **applied industrially**

to obtain products which **market prices typically < 2€/kg**

with units working **350 days/year on a 24/7 basis**

**with typical capacities of 100 kT / year**

**Citric Acid**

**Succinic acid**

**1,4 BDO**

**Glucose**

**Lysin**

**1,3 PDO**
Ceramic Membranes - References

Novasep Process Industrial Biotech
Ceramic membranes installed capacity
Chromatography references

<table>
<thead>
<tr>
<th>Examples</th>
<th>Product price</th>
<th>Installed capacity</th>
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<tbody>
<tr>
<td>Fructose HFCS</td>
<td>0.7 €/kg</td>
<td>1710 kT / y</td>
</tr>
<tr>
<td>Citric acid</td>
<td>0.8 €/kg</td>
<td>135 kT / y</td>
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Novasep Process Industrial Biotech
Low pressure chromatography installed capacity

Purification: a Challenge for Drop-In Bio-Based Chemicals
Applications

- Sweet and lactic acid whey
- Lactulose syrup
- Casein whey
- Organic acid conversion
Success Stories
Succinic Acid Purification

- Succinic acid is a key chemical intermediate
- Customer: JV ARD – BioAmber
- Process development work started in 2004
  - Technology Screening
  - Process Simulation
  - Process integration
  - Piloting work
- 1\textsuperscript{st} industrial Bio Succinic Acid plant worldwide started in 2009, with Capacity 3,000 t/year
- Other studies on-going (more than 6 routes studied)
Succinic Acid Purification

- Clarification by Kerasep® membrane filtration

- 2 different processes, depending on local conditions:
  - Applexion® CIEX
  - Novasep – Mega®Electrodialysis
Customer: confidential
Molecule: chemical polyol, confidential
Process development work started in 2007
- Technology Screening
- Process simulation
- Process integration
- Piloting work
1st industrial plant started in 2008
Extension made in 2012
Other studies on-going
Chemical Polyol Purification

- Separation of chemical polyol and salts by Applexion® SSMB, on ion exclusion principle
- Concentration by reverse osmosis
- Separation of chemical polyol and sugar by Applexion® SSMB, on affinity principle
Our References
Main Experience With

Lactic Acid
Succinic acid
Citric Acid
Lysin
Oligosaccharides
Lignin
Sorbitol
Gluconic acid
MSG
1,4 BDO
Mannitol
Gluconic acid
1,3 PDO
Mannose
GMP
Fructose
IMP
Glucose
Arabinose
Glucaric acid
Threonin
Itaconic acid
Xylose
Thank you for your attention!

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