



# Novasep Process: Advanced Purification Technologies for Bio-Based Chemicals

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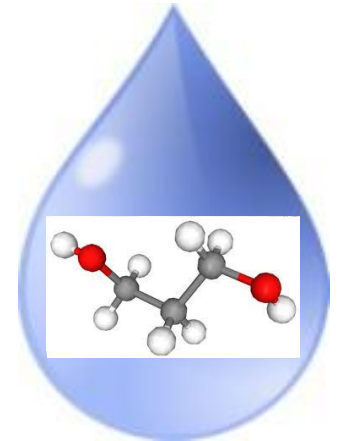
Pacific Rim – Industrial Biotechnology and Bioenergy

Vancouver, BC  
October 12th, 2012

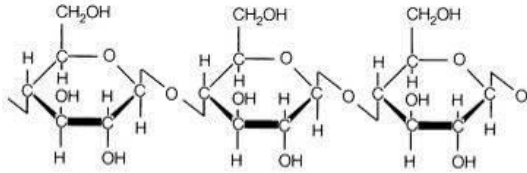
# Producing Bio-Based Chemicals



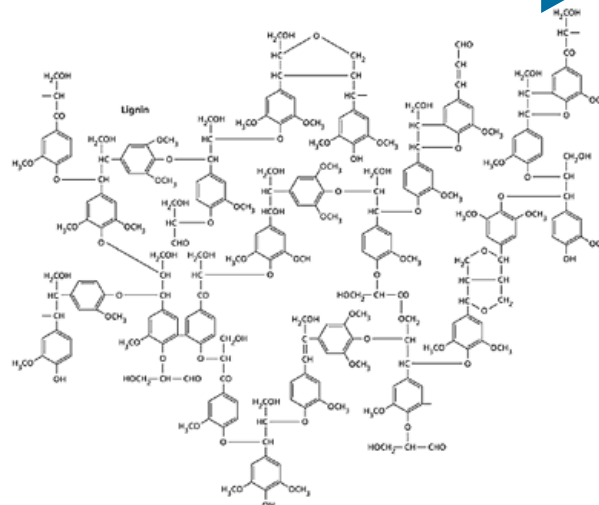
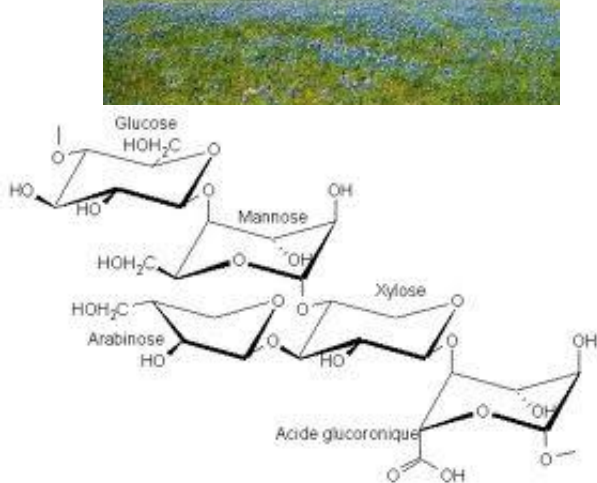
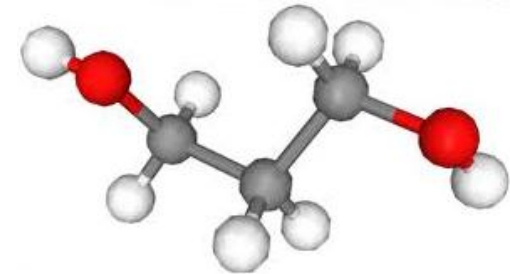
The challenge!



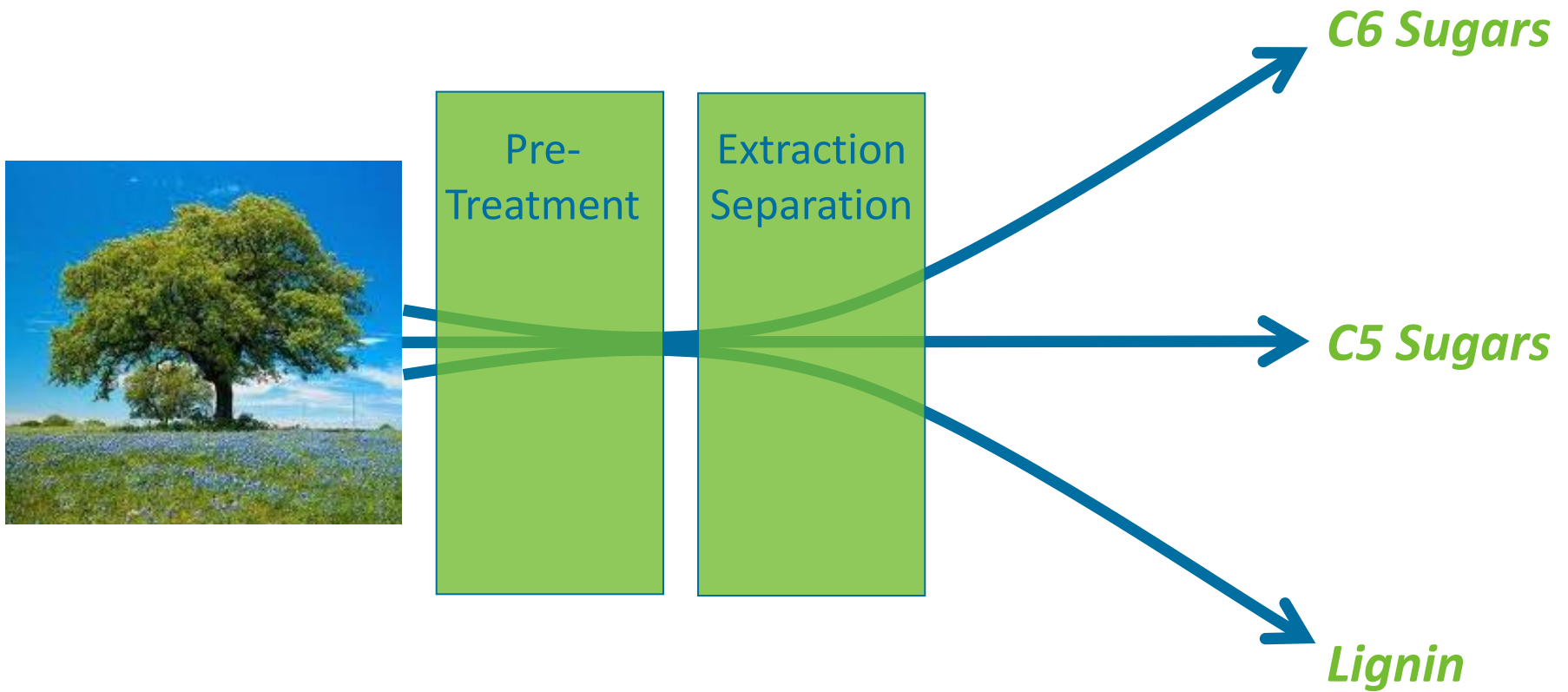
# Another View of the Challenge



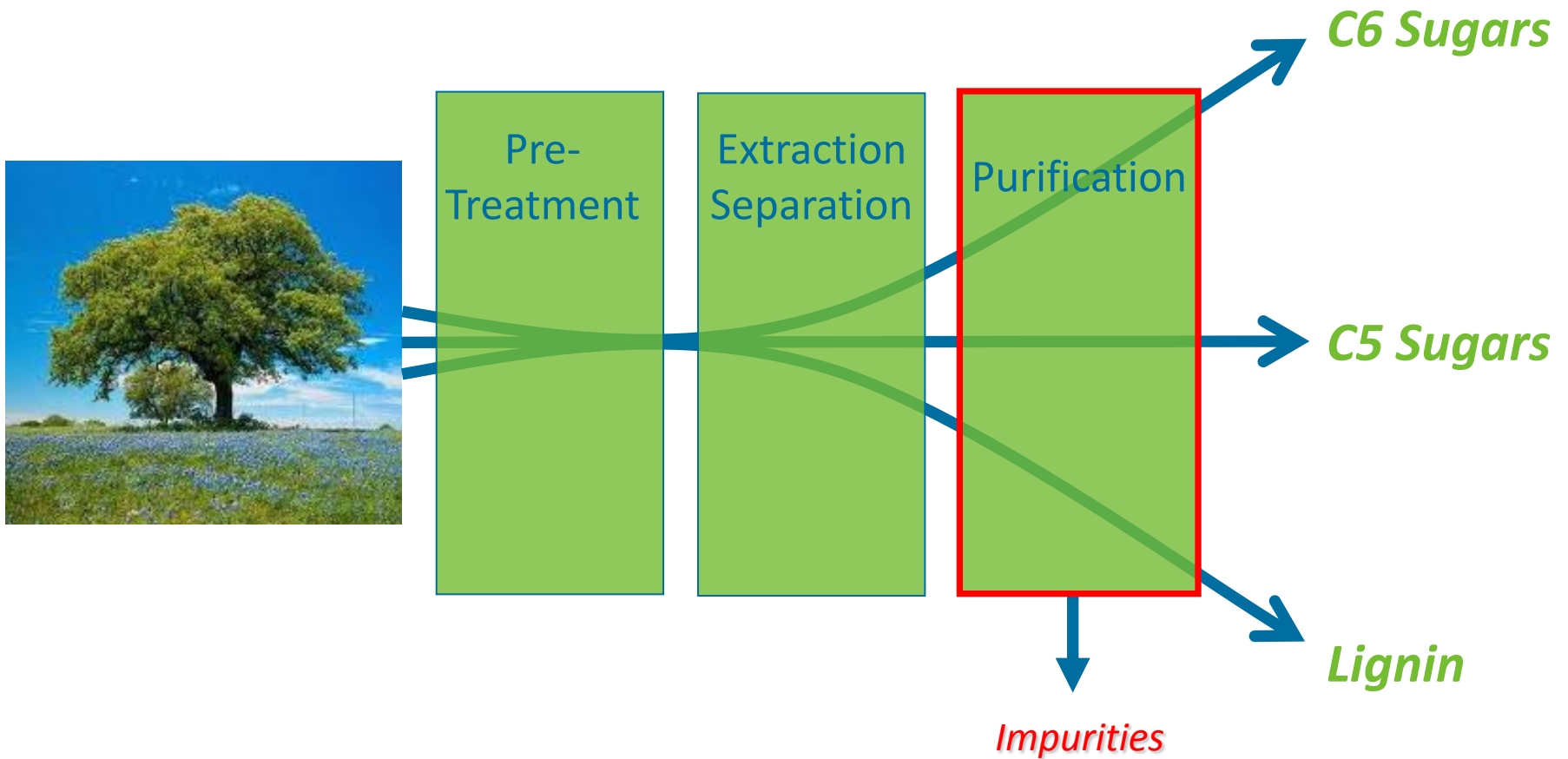
The challenge!!



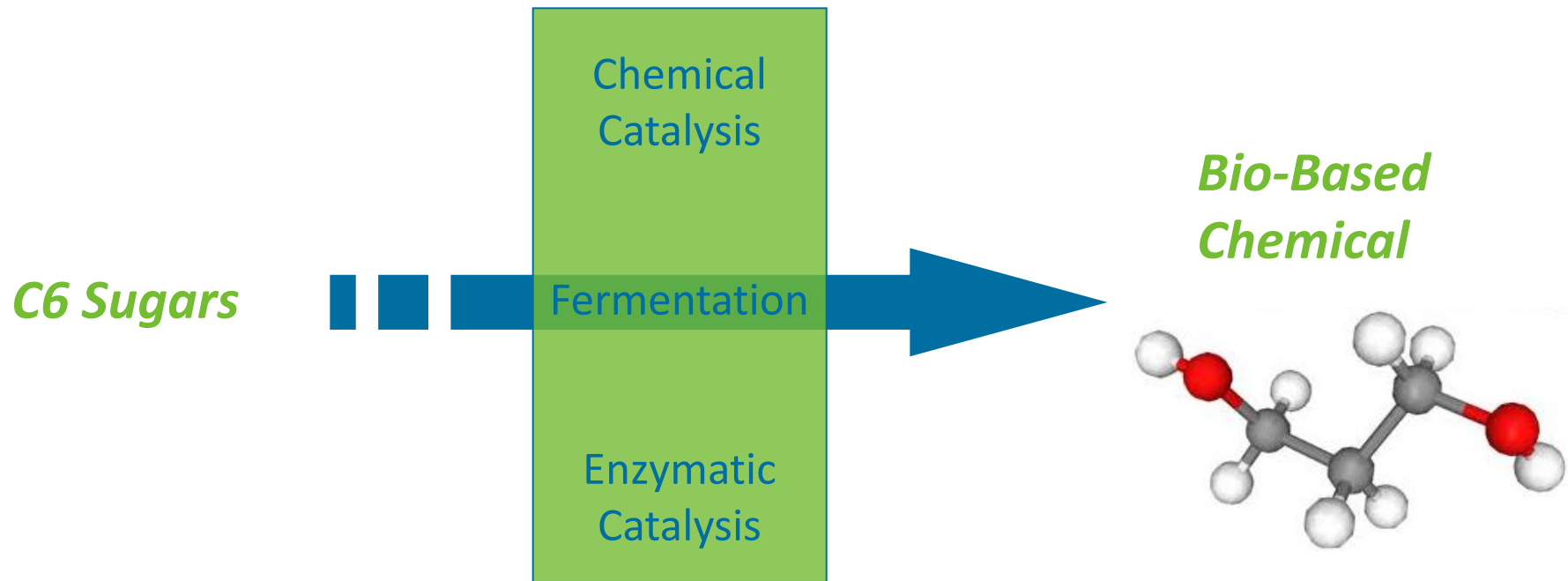
# Cracking Biomass



# How to Get Pure Fractions?

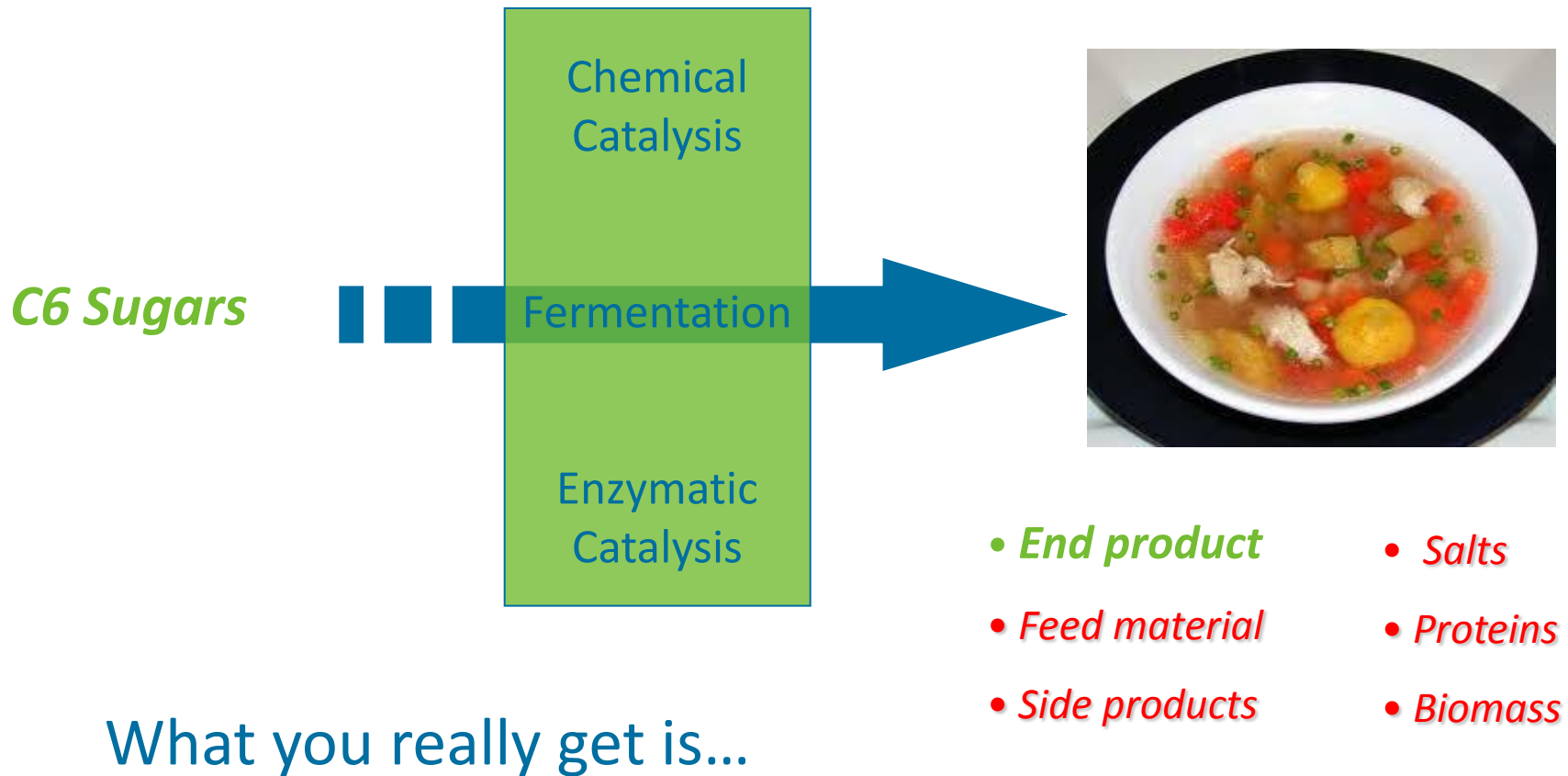


# Producing Bio-Based Chemicals

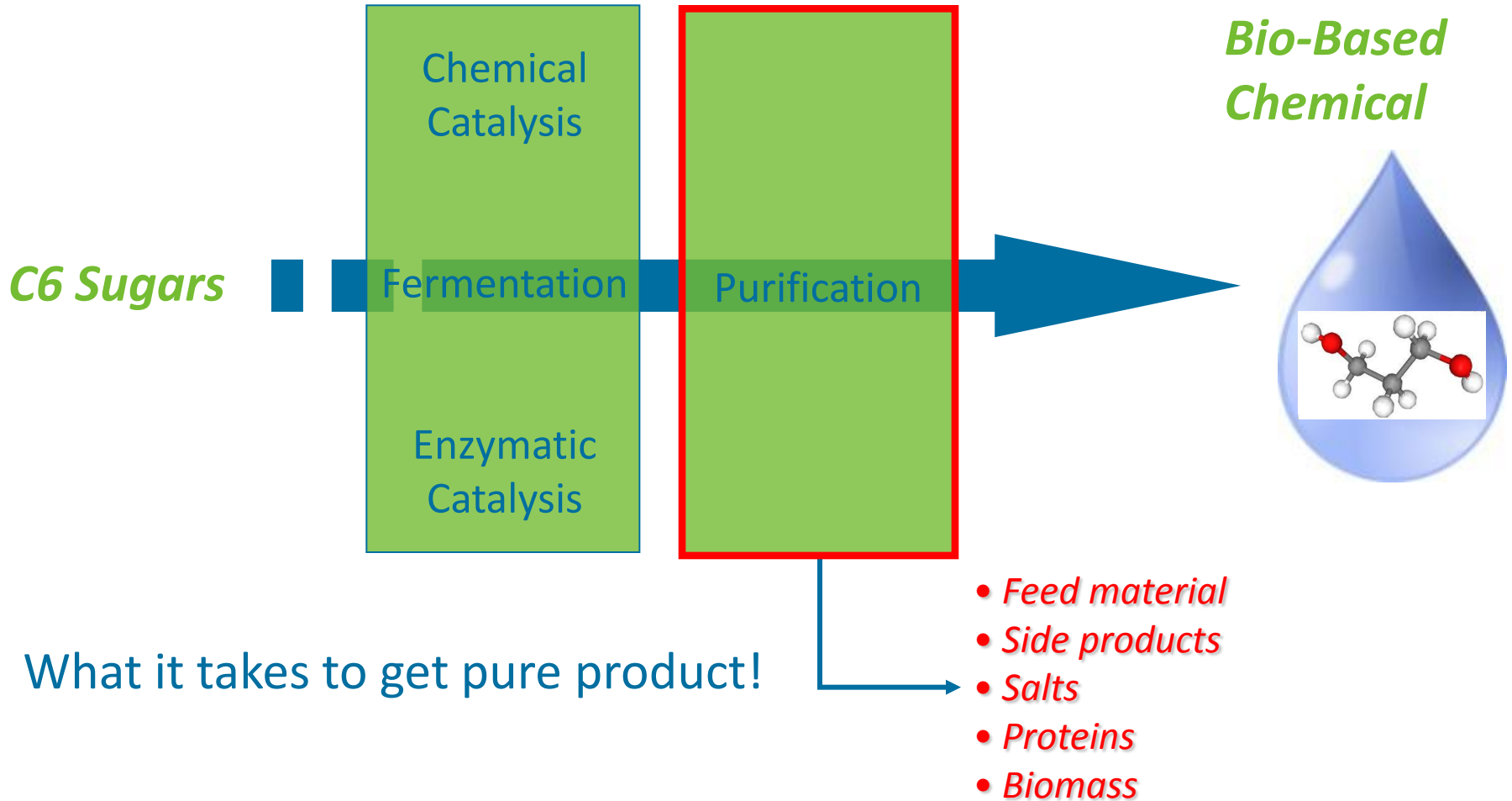


What you think you will get?

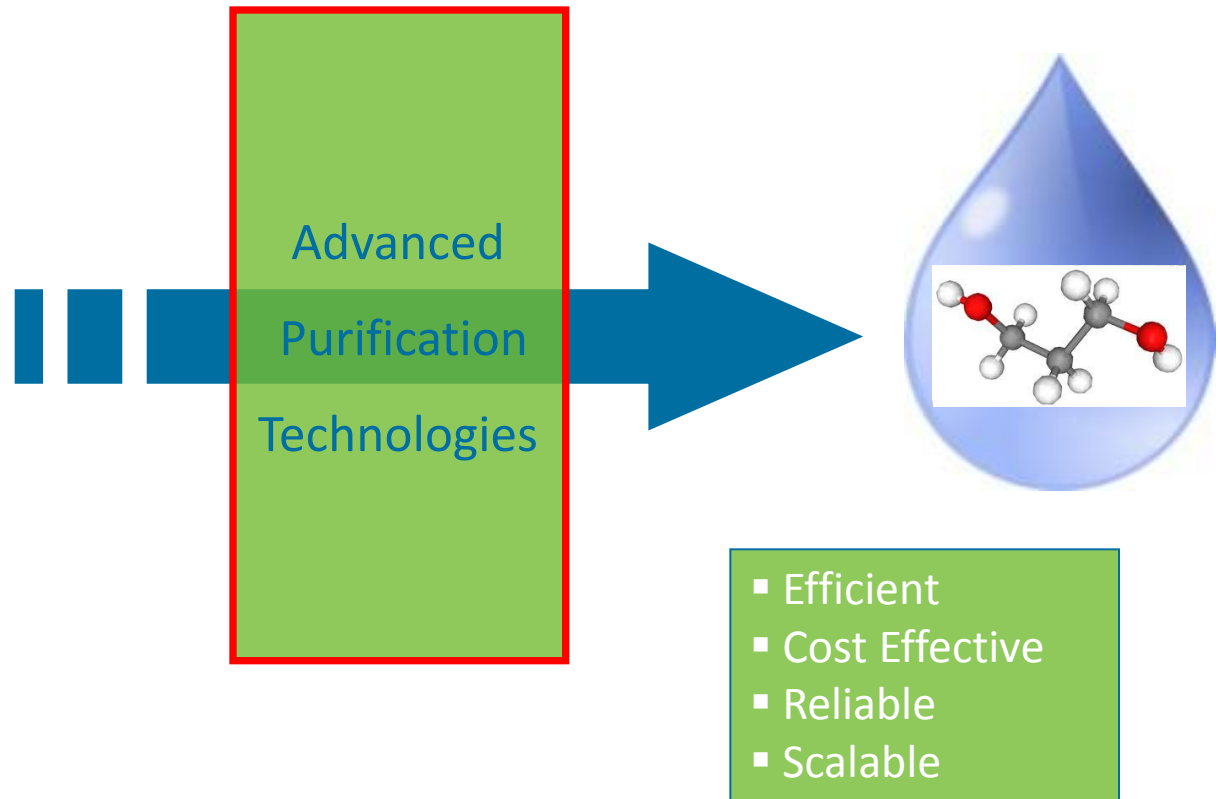
# Producing Bio-Based Chemicals



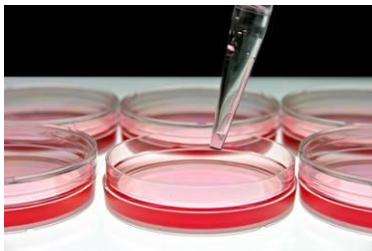
# Producing Pure Chemicals







## Biopharma



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

## Food Ingredients



Sugar  
Starch  
Milk

## Functional Ingredients



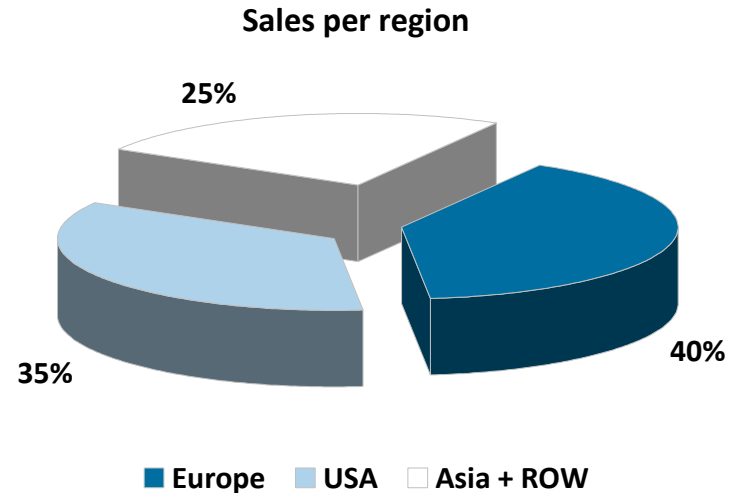
Polyphenols  
Anthocyanes  
FOS  
Sweeteners

## Bio-Industries



**White Biotechnology**  
Organic Acids  
Aminoacids  
Antibiotics  
Vitamins

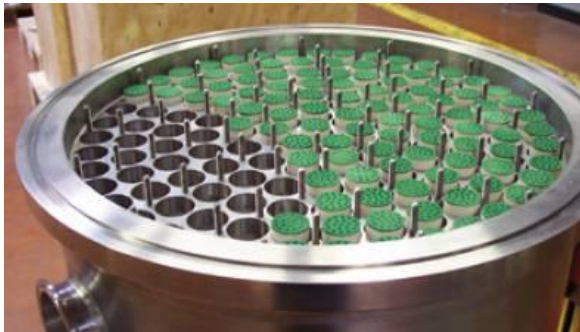
2011 revenues: \$400 M  
1200 employees, 200 in R&D



Over **100 R&D projects** per year  
Over **100 active molecules** produced per year  
Over **2,000 purification systems** installed worldwide  
Over **650 customers** served worldwide

# Technologies

## An Unparalleled Breadth of Key Unit Operations



# An Unparalleled Breadth of Key Unit Operations

## Continuous chromatography

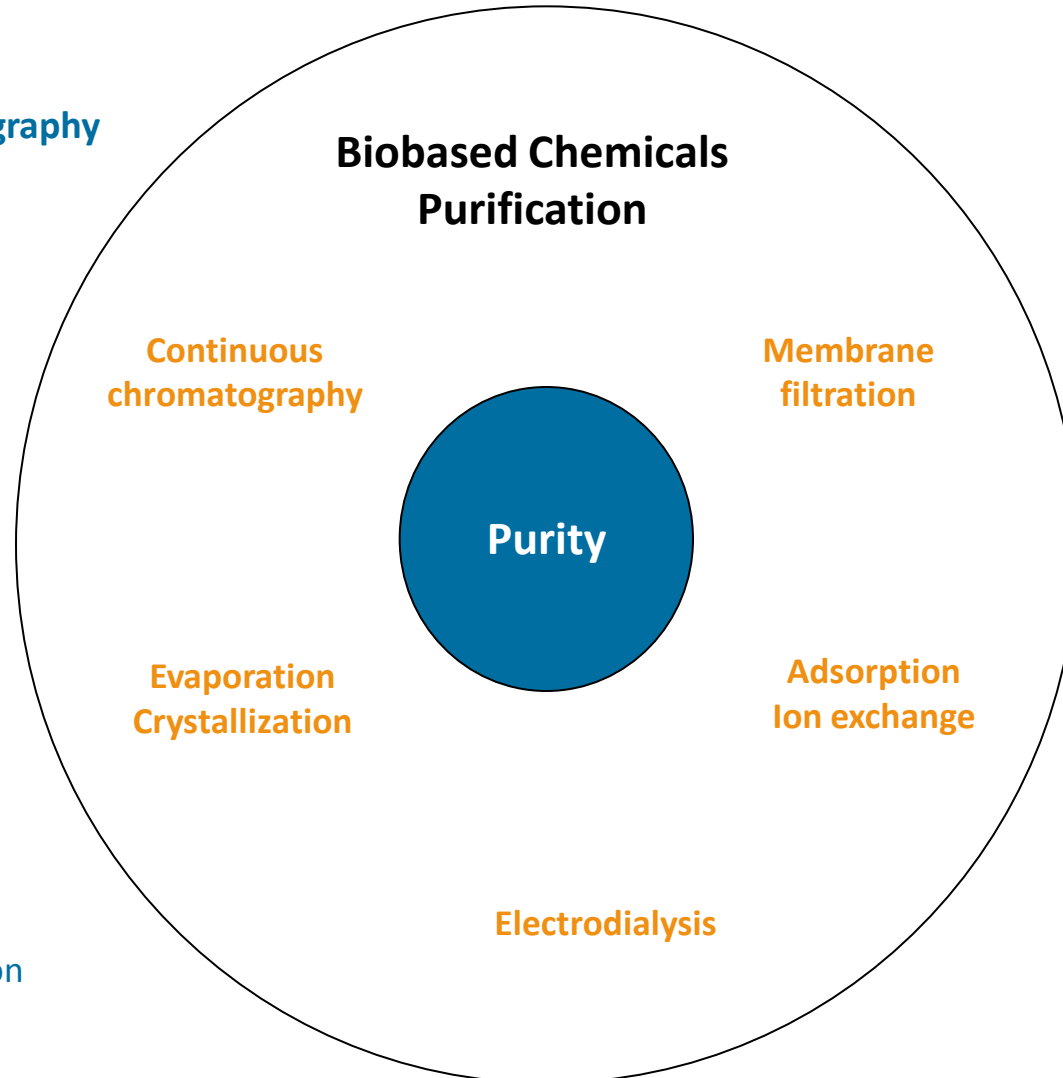
- Applexion® SSMB
- Separation of fractions
- Purification

## Evap/Crystallization

- Plate or tubular
- Multiple effect
- MVR

## Electrodialysis

- Demineralization
- Salt Conversion



## Membrane filtration

- Organic & Ceramic
- Clarification
- Concentration

## Adsorption/IEX

- Salt conversion
- Demineralization
- Decolorization
- Batch or Continuous

# Kerasesp® Filtration Membranes

- Ceramic membranes: Kerasesp®
- Micro and Ultrafiltration
- Applications:
  - Clarification of fermentation broth
  - Purification and concentration of enzymes



- Feed: 1550 m<sup>3</sup>/day – 240 g/L
- Target recovery: 99%
- Carousel design with 14 skids
- 2 CIP systems
- Up to 6 years lifetime guarantee
- Installed Base > 100 000 m<sup>2</sup>

# Ion Exchange and Adsorption

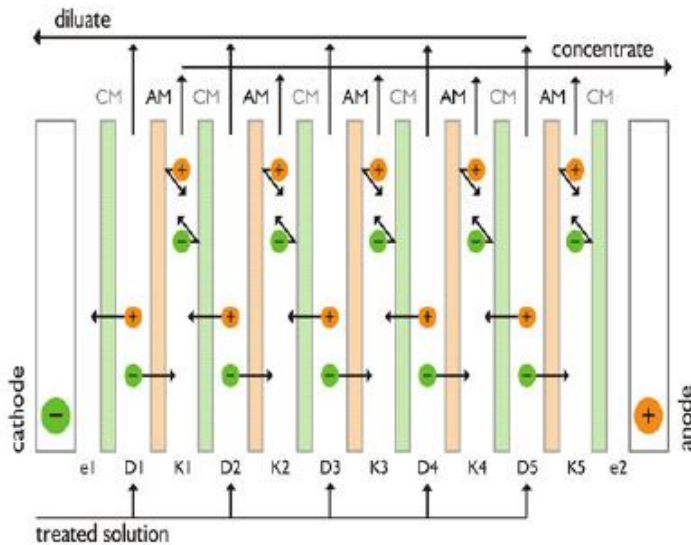
- Batch and continuous ion exchange
- Adsorption on resins and activated carbon
- Applications: decolorization, desalting, purification and salt conversion



Low consumption of:

- Chemicals
- Water

- ED: transport salts from one solution through ion exchange membranes to another solution by way of an electrical current
- Applications: desalting and purification of sugars, organic acids

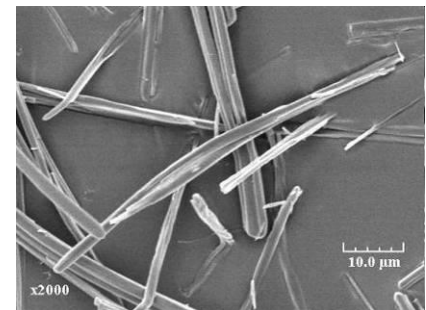


- High desalting efficiency
- No effluents generation
- No chemicals consumption



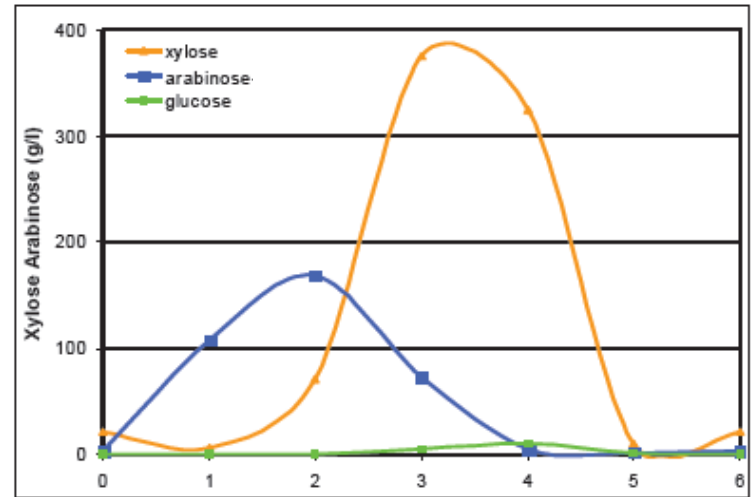


- Multiple effect, MVR or TVR
  - Plate or tubular evaporators
  - FF and FC
  - Applications:
    - Citric acid
    - Mineral salts
    - Sugars
    - Vinasses
- High energy efficiency
  - Thermal integration in your plant
  - Experience with scaling products

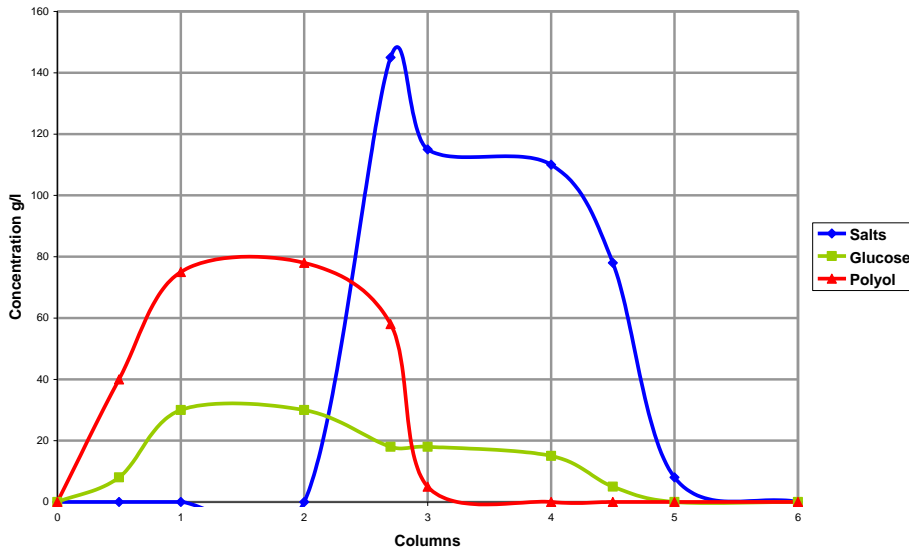


# Applexion<sup>®</sup> SSMB Chromatography

- Affinity chromatography:
  - Xylose / Arabinose / Glucose separation
  - Glucose / Mannose
  - Polyols



- Ion exclusion:
  - Sugar and salt separation
  - Polyol demineralization



- High purity fractions
- Low water usage
- No chemical consumption

## The Lab HPLC Equipment!



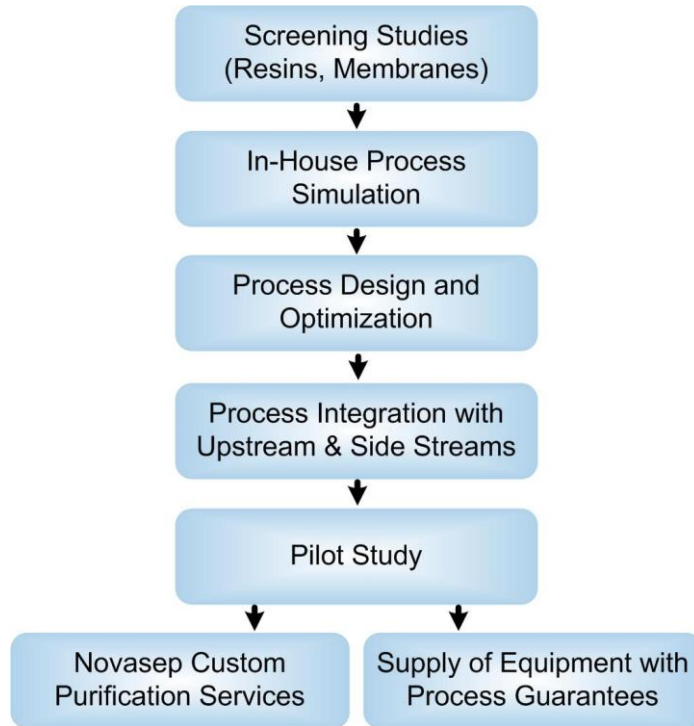
# Applexion<sup>®</sup> SSMB Chromatography



## The Industrial Process!

Commonly used for:

- Glucose
- Fructose
- Vinasses / Stillages
- Citric acid



- 50 pilots available in Europe, USA and China
- 20 processes in Industrial Biotech developed each year

Technology + Know-How + Process Development  
=  
Your Process Performance Guaranteed!

# CASE STUDY 1: Succinic Acid Purification

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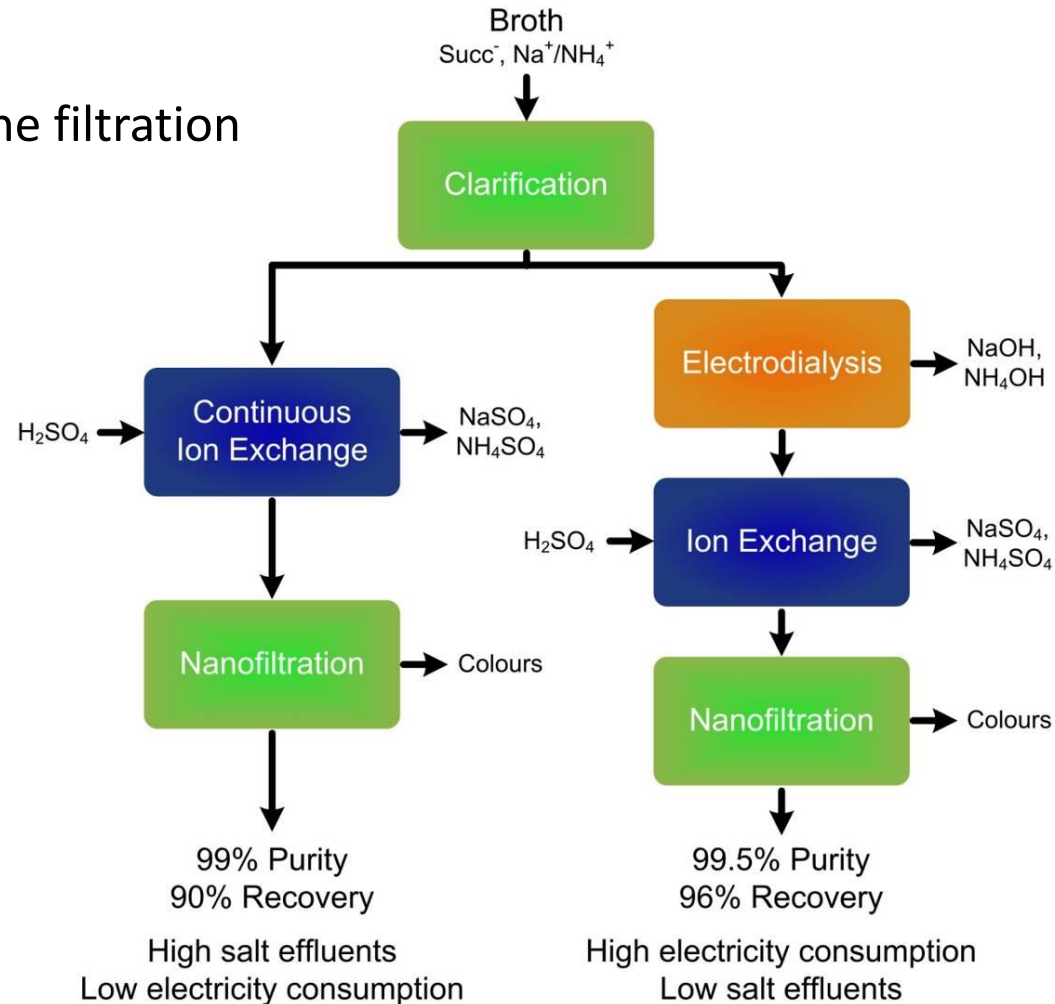
- Succinic acid as a key chemical intermediate
- Customer: JV ARD – BioAmber
- Process development work started in 2004
  - Technology Screening
  - Process Simulation
  - Process integration
  - Piloting work
- 1<sup>st</sup> industrial Bio Succinic Acid plant worldwide started in 2009, with Capacity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

# CASE STUDY 1: Succinic Acid Purification

- Clarification by Kerasep<sup>®</sup> membrane filtration

- 2 different processes, depending on local conditions:

- Applexion<sup>®</sup> CIEX
- Novasep – Mega<sup>®</sup> Electrodialysis





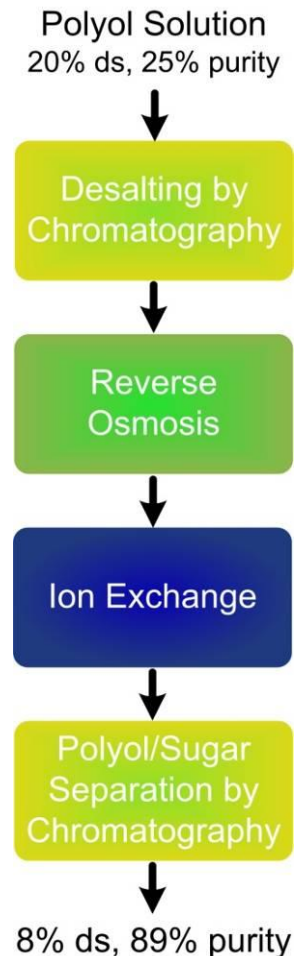
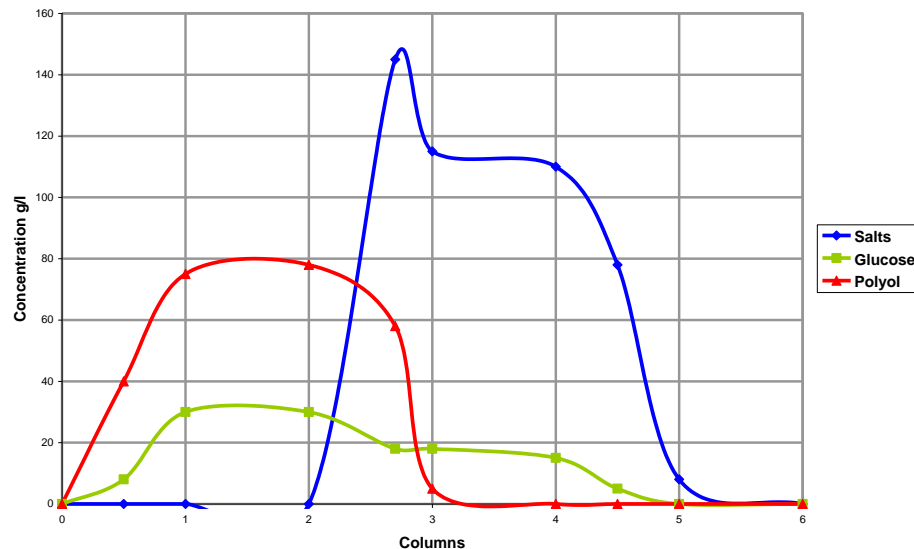
## CASE STUDY 2: Chemical Polyol Purification

- Customer: confidential
- Molecule: chemical polyol, confidential
- 99% purity, 99% recovery
- Process development work started in 2007
  - Technology Screening
  - Process simulation
  - Process integration
  - Piloting work
- 1<sup>st</sup> industrial plant started in 2008
- Expansion to increase the throughput in 2011
- Further expansion of certain unit operations in 2013



## CASE STUDY 2: 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



## Membranes, Chromatography, IEX, Electrodialysis

=

**VERY Efficient, cost-effective, reliable** and **scalable** technologies

Allowing to reach **high degrees of purity**

& relying on the use of various physio-chemical properties :

pKa

Molar mass

Hydrogen bonds

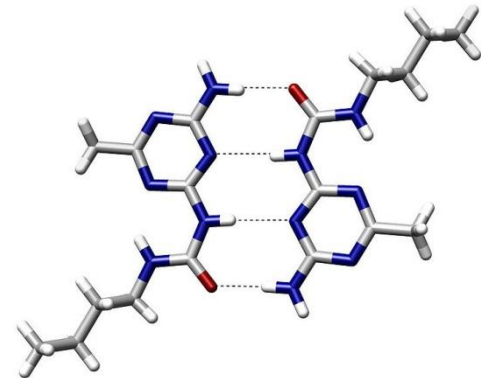
Solvation size

Isoelectric point

Hydrophobic/hydrophilic interactions

Polar/non polar interactions

Molecular Geometry configuration



Novasep Process designs **optimized** and **integrated** process routes, selected among competitive technologies depending on local conditions, and applied industrially to obtain products which market prices typically < \$3/kg

**Lactic Acid**

**Mannose**

**Itaconic acid**

**Succinic acid**

**Citric Acid**

**Glucose**

**Arabinose**

**Oligosaccharides**

**Lysin**

**GMP**

**Glucaric acid**

**Gluconic acid**

**Sorbitol**

**Fructose**

**Threonin**

**MSG**

**1,4 BDO**

**IMP**

**Xylose**

**1,3 PDO**

**Mannitol**



Here's to your success!

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