Isolation 2,3-BD generated from syngas fermentation. Projection at industrial scale

SYNPOL´s Course on “Biopolymers from bacterial fermentation of syngas”

Auditorio del Centro de Investigaciones Biológicas (CIB-CSIC)
Madrid, 9 September 2016

Isabel De Los Ríos –Downstream Process Engineer
Chemical Engineering Graduate
isabel.rios@bionet.com
1. BIONET

2. Process development methodology for “Isolation 2,3-BD generated from syngas fermentation. Projection at industrial scale”.

3. Conclusions
1. BIONET

2. Process development methodology for “Isolation 2,3-BD generated from syngas fermentation. Projection at industrial scale”.

3. Conclusions
BIONET is an independent SMEs. We are specialists in bioprocesses engineering, founded in 1999. Located in Murcia, in SE of Spain.

1. BIONET

a) Bioprocess Equipment
- Bioreactors/fermentors
- Membrane filtration systems
- Cleaning-in-place systems
- Ancillary vessels (harvest, media preparation, extraction..)
- Process automation

b) Services
- Process development
- Process engineering
- Turnkey of process lines
- Training
- Maintenance and troubleshooting
1a. Process equipment

- From pilot to industrial scale
- For microbiology and cell culture
- Available in Food/Industrial grade (A) and cGMP (P)
The **objective** of BIONET process development services is:

- Define feasible processes
- Reduce risks in the scale-up
- Reduce “time-to-market”
- Ensure the viability of new developments.

**Resources:**
- Dedicated process department.
- Pilot plant with fermentors, bioreactors, downstream equipment to work from 2 L to 200 L.
- Network of scientific and technological partners.
1. BIONET

2. Process development methodology for “Isolation 2,3-BD generated from syngas fermentation. Projection at industrial scale”.

3. Conclusions
2. Process development methodology

Objective: 2,3-BD isolation from fermentation broth
Main KPI: % 2,3-BD recovery

1. Operating conditions and limitations
   - definition: not defined
2. Design bases definition: 120 h, FB composition
3. KPIs definition: primary and secondary

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2. Process development methodology

Project challenges

Basic operations definition

Technologies screening and selection

Process configuration

Validation

Economic evaluation

Optimization

Objective: 2,3-BD isolation from fermentation broth

Main KPI: % 2,3-BD recovery

1. Operating conditions and limitations: not defined
2. KPIs definition: primary and secondary
3. Design bases definition: 50 m³, 120 h, FB composition

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BASIC OPERATIONS DEFINITION

Project challenges → Basic operations definition → Technologies screening and selection → Process configuration → Validation → Economic evaluation

Optimization

Inoculation → Harvest

1st area
Upstream
- Conditioning
- Pre-treatment

2nd area
Midstream
- Fermentation

3rd area
Downstream
- Dewatering
- Isolation
- Purification
2. Process development methodology

**BASIC OPERATIONS DEFINITION**

1. **1st area**
   - **Upstream**
     - Conditioning
     - Pre-treatment

2. **2nd area**
   - **Midstream**
     - Anaerobic fermentation

3. **3rd area**
   - **Downstream**
     - Dewatering
     - Isolation
     - Purification

- **Inoculation**
- **Harvest**

- **2,3-BD extraction**
- **2,3 BD concentration / solvent recovery**
- **Biomass removal**
2. Process development methodology

2. Process development methodology

Project challenges ➔ Basic operations definition ➔ Technologies screening and selection ➔ Process configuration ➔ Validation ➔ Economic evaluation

Optimization

BASIC OPERATIONS DEFINITION

1\textsuperscript{st} area

Upstream

Conditioning

Pre-treatment

Pyrolysis

Black boxes

2\textsuperscript{nd} area

Midstream

Fermentation

Anaerobic fermentation

3\textsuperscript{rd} area

Downstream

Dewatering

Isolation

Purification

2,3 BD concentration / solvent recovery

Inoculation ➔ Harvest

Biomass removal

2,3-BD extraction

Student challenges

Process configuration validation

Basic operations definition

Technologies screening and selection

Economic evaluation

Optimization
TECHNOLOGIES SCREENING AND SELECTION

2. Process development methodology

- Project challenges
- Basic operations definition
- Technologies screening and selection
- Process configuration
- Validation
- Economic evaluation

Optimization

3rd area: Downstream

- Dewatering
  - Biomass removal
    - Centrifug.
    - Filtration
    - Decantation
    - Flotation
  - 2,3-BD extraction
    - Precipitation
    - ATPS
    - Evaporation
    - Distillation
    - Pervaporat.
- Isolation
- Purification
  - 2,3-BD purification
    - Distillation
    - Chromatog.
    - Pervaporat.

Screening

- Literature research
- Vendor consult.
- Patents search
- Training courses
- Visit existing plants
- BIONET background
## 2. Process development methodology

### Technologies screening and selection

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### KPIs ranking

**Primary**
1. %2,3-BD recovery
2. Operating costs
3. Investment costs
4. TRL

**Secondary**
1. 2,3-BD purity
2. Energy consumption
3. Water consumption
4. Special requirements

### Technologies matrix

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2. Process development methodology

TECHNOLOGIES SCREENING AND SELECTION

3rd area: Downstream

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Screening ➔ Selection
INDUSTRIAL PROCESS MODEL CONFIGURATION

3rd area: Downstream

Dewatering
- Biomass removal
  - Centrifugation

Isolation
- 2,3-BD extraction
  - Precipitation

Purification
- 2,3-BD purification
  - Distillation

Project challenges
Basic operations definition
Technologies screening and selection
Process configuration
Validation
Economic evaluation

Optimization

PFD
Mass balance
Energy balance
Yields
Cyclogram

Model

2. Process development methodology
2. Process development methodology

INDUSTRIAL PROCESS MODEL CONFIGURATION

3rd area: Downstream

Dewatering
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Isolation
- 2,3-BD extraction
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Economic evaluation
- Validation
- Technologies screening and selection
- Basic operations definition
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Optimization
2. Process development methodology

INDUSTRIAL PROCESS MODEL CONFIGURATION

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**Project challenges**
- Basic operations definition

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**Validation**

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2. Process development methodology

INDUSTRIAL PROCESS MODEL CONFIGURATION

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**Optimization**
INDUSTRIAL PROCESS MODEL CONFIGURATION

Project challenges
Basic operations definition
Technologies screening and selection
Process configuration
Validation
Economic evaluation

Optimization

2. Process development methodology

FINAL INTEGRATION

Ancillaries operations
2. Process development methodology

- Project challenges
- Basic operations definition
- Technologies screening and selection
- Process configuration
- Validation
- Economic evaluation

PROCESS VALIDATION AND OPTIMIZATION

- Operating conditions optimization
- Basic operations yields
- Raw material requirements
- Global yield

If TRL < 6 → experimental validation
2. Process development methodology

PROCESS VALIDATION AND OPTIMIZATION

Feedback = upgrade

GLOBAL PROCESS VALIDATION
2. Process development methodology

**ECONOMIC EVALUATION**

**Project challenges**
- Basic operations definition
- Technologies screening and selection
- Process configuration
- Validation
- Economic evaluation

**ECONOMIC EVALUATION**

**Possible process configuration**

**Economic evaluation**

- **CAPEX**
  - List of main process equipment
- **OPEX**
  - Bibliographical extrapolation factors
  - Utilities and raw materials consumptions
- **RISK ASSESSMENT**
  - Severity of effect
  - Probability of failure

**FINAL PROCESS CONFIGURATION**

**Optimization**
2. Process development methodology

- Project challenges
- Basic operations definition
- Technologies screening and selection
- Process configuration
- Validation
- Economic evaluation

ECONOMIC EVALUATION

CAPEX
- Investment: 3 MM €
- ATEX and continuous plant

OPEX
- Utilities: steam, chiller and hot water, electricity.
- Maintenance, labor and others

RISK ASSESSMENT
- Economical risk: far from being competitive. Side-products sales
- Technological risk: low TRL

Bottlenecks definition
2. Process development methodology

Bottlenecks definition
- Low 2,3-BD concentration in harvest broth
- High raw materials consumption
- Technologies with low TRL and very specific
- Industrial production by synthesis widely applied

Economical risk: far from being competitive. Side-products sales
Technological risk: low TRL
1. BIONET

2. Process development methodology for “Isolation 2,3-BD generated from syngas fermentation. Projection at industrial scale”.

3. Conclusions
- Identify clear and measurable objectives
- Identify clear and measurable KPIs
- Establish a clear KPIs ranking
- Be methodical
- Know benchmarks
- Robust and reliable technologies
- Iterations = optimization
THANKS FOR YOUR ATTENTION!!!!!

QUESTIONS???

Isabel De Los Ríos – Downstream Process Engineer
Chemical Engineering Graduate
isabel.rios@bionet.com

Bionet Engineering
Av Azul 2.11, Parque Tecnológico Fuente Álamo
30320 Fuente Álamo, Spain
Office +34 902 170 704
www.bionet.com