**Biomass Pretreatment**

**Equipment overview:**

**Reactors for chemical pretreatment of biomass:**
These reactors are suitable for acid ($\text{H}_2\text{SO}_4$, HCl…), alkaline [NaOH, ammonia…], sulfite, organosolv and other types of pretreatment:
- 1 x 5400 L (ATEX, glass lined, pressurized)
- 1 x 1000 L (ATEX, glass lined, pressurized)
- 1 x 500 L (ATEX, glass lined, pressurized)
- 1 x 85 L (ATEX, glass lined, pressurized)

**Reactors for enzymatic hydrolysis of biomass:**
- 3 x 50 000 L
- 4 x 8000 L
- 2 x 5000 L
- 2 x 4000 L
- 1 x 1000 L
- 1 x 500 L
- Lab scale hydrolysis

**Reaction vessels for slurries with high solids contents**

**Auxiliary equipment:**

- **Milling**
  - Dry milling: roller crusher, knife mill, hammer mill, cutting mill, pin disk mill
  - Wet milling: pulper (2000 L), inline mixer, inline colloid mixer

- **Thermal treatment**
  - Direct steam injection
  - Jet cooking with holding tube

- **Dewatering and concentration equipment**
  - Filter press
  - Decanter centrifuge
  - Screw press
  - Falling film three-effect evaporator, 5 t/h water evaporation
  - Wiped film evaporators, 2 kg/h and 150 kg/h water evaporation

**What we offer:**

- Mechanical, thermal, physico-chemical and enzymatic pretreatment of biomass feedstocks
- Logistics and storage:
  - Truck (un)loading docks
  - Bulk solid biomass storage
    - [55 t silo, 3x90 t bunkers]
  - Liquid storage (vessels up to 125 m³)
  - Dedicated areas for IBC storage
  - Chemicals storage outside production halls
  - Refrigerated storage room, freezers
- A wide spectrum of modular operation units

**Relevant expertise:**

Experience in treating the following lignocellulosic raw materials:

- Agro-industrial side streams: paper pulp, spent grains, bagasse, press cakes, stillage...
- Agronomic by-products: corn stover, corn cobs, husk, fiber, stems, leaves, verge grass...
- Dedicated energy crops: miscanthus, poplar...

For more information: please visit www.bbeu.org

For questions, please call +32 9 335 70 01 or send an email to BusDev@bbeu.org
BIOCATALYSIS
Equipment overview:

Process vessels for aqueous reactions:
- 3 x 50,000 L
- 4 x 8000 L
- 2 x 5000 L
- 2 x 4000 L
- 1 x 1000 L
- 1 x 500 L

Process vessels for solvent-based reactions:
- 1 x 5400 L (ATEX)
- 1 x 1000 L (ATEX)
- 1 x 500 L (ATEX)
- 1 x 85 L (ATEX)
- 1 x 7 L (ATEX)

Reaction vessels for suspensions with high solids contents

Auxiliary equipment:
- Fermenters of different sizes to produce the biocatalyst [see fermentation brochure]
- A variety of downstream purification equipment to purify the product of interest from the reaction mixture [see product recovery and purification brochure]

What we offer:
- Scale-up and demonstration of biocatalytic processes
- Process development and optimization
- Custom manufacturing
- Single enzyme or whole cell biocatalyst systems
- Immobilization of enzymes and whole cells
- Aqueous and solvent based reactions
- Enzyme or whole cell biocatalyst production through bacterial, yeast or fungal fermentation

Relevant expertise:
BBEP’s team of process and R&D engineers has built up a significant track record in production of biocatalysts and in biocatalytic conversions at lab and pilot scale. The team has demonstrated various aqueous and solvent based reactions at an industrially relevant scale.

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FERMENTATION
Equipment overview:

(An)Aerobic fermenters: 
- batch, fed-batch, continuous
  - 2 x 15000 L
  - 1 x 4500 L
  - 2 x 1500 L
  - 4 x 150 L
  - 1 x 50 L
  - 5 x 7 L

Anaerobic fermenters: 
- 1 x 5400 L [ATEX]
- 1 x 1000 L [ATEX]
- 1 x 500 L [ATEX]
- 1 x 85 L [ATEX]

Gas fermenters, feed CO, CO₂, H₂: 
- 1 x 7 L [ATEX]

Auxiliary equipment: 
- Analytical capabilities: HPLC, GC off gas analysis and data logging.
- Biomass pretreatment equipment for second generation bioproducts [see Biomass pretreatment brochure]
- A variety of downstream processing equipment to recover and purify the product of interest from the fermentation broth [see Product Recovery and Purification brochure]

What we offer: 
- Scale-up and demonstration of fermentation processes
- Batch, fed-batch and continuous (with or without cell recycle) fermentations
- Experience with bacterial, yeast and fungal systems
- Process development and optimization
- Custom manufacturing
- Examples of products: industrial enzymes, fine and bulk chemicals, biofuels, biochemicals, bioplastics, biosurfactants, biosolvents, nutraceuticals, food ingredients, bioflavours...

Relevant expertise: 
Our team combines over 50 years of fermentation experience. We can rely on fermentation experts with academic and industrial backgrounds. This combination makes our expertise unique.

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GREEN CHEMISTRY

Equipment overview:

Glass lined, pressure proof and corrosion resistant reactors, coupled to a condenser and vacuum pump.

Properties:
- Pressures up to 9 bar
- Temperatures up to 200°C.
- Vacuum down to 20 mbara

Reactor volumes (ATEX):
- 1 x 5400 L
- 1 x 1000 L
- 1 x 500 L
- 1 x 85 L
- 1 x 7 L

Auxiliary equipment (ATEX):
- Filter dryer (1900 L)
- Conical dryer (980 L)
- Bag filter
- Filter press
- Basket centrifuge (40 kg)
- Continuous liquid-liquid extraction column 10 L/h

What we offer:

ATEX compliant installation and expertise for chemical processes:
- Solvent evaporation and condensation
- Zoning of the operational area to ATEX zone 2
- Explosion protection on all electrical equipment: ExII2G T3
- N2 inertisation and blanketing
- Pressure proof from -1 to 9 bar

Types of processes:
- Chemical synthesis reactions
- Chemical conversion reactions
- Chemical hydrolysis
- Extractions

Relevant expertise:

ATEX zoning challenges the possibilities and freedom of operation. However, our team of experienced engineers and operators can always find a safe and workable approach. Our team is ready to bring your product to the next level.

Examples:

- Functionalisation of biopolymers and oligosaccharides
- Esterification of fatty acids
- Synthesis of oleochemicals
- Chemical synthesis of biosurfactants
- …

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PRODUCT RECOVERY AND PURIFICATION
The equipment overview below gives an idea of the variety of modular operation units we have available to perform your purification and product recovery processes. However, this list is not complete. If you are looking for specific equipment not listed below, do not hesitate to contact us.

Equipment overview:

Centrifugation
- High speed disc stack centrifuges, 500 L/h and 3 m³/h
- Screw decanter centrifuge, 750 kg/h
- Basket centrifuges, 10 kg and 40 kg
- Inverting filter centrifuge, up to 50 kg of product per cycle

Membrane Filtration:
- Cross-flow membrane filtration units for Micro, Ultra & Nanofiltration
- Different membrane types: spiral wound, hollow fiber, ceramic

Filtration:
- Dead-end filtration such as plate and frame filters, candle filter
- Filter presses
- Rotary vacuum drum filter, basket filter

Ion exchange and adsorption
Columns for ion exchange, adsorption or activated carbon treatment
- 3 x 30 L resin
- 4 x 800 L resin

Crystallization
- Various reactors from 50 L to 4 m³ for cooling crystallization and evaporation crystallization
- Crystallization line up to 1000 t/y equipped with crystallizer 4 m³, inverted basket centrifuge, crystal dryer
- Continuous cooling crystallization unit 50 L

Evaporation
- Continuous evaporation units from liter to ton scale
- Falling film three-effect evaporator, 5 t/h water evaporation
- Wiped film evaporators, 2 kg/h and 150 kg/h
- Spinning cone evaporator, up to 50 kg/h water evaporation
- Batch evaporation reactors for both water and solvent based distillation

Extraction
- Filter dryer 1900 L (ATEX) for solvent extraction and solids drying
- Karr column (6 L/h) for countercurrent liquid–liquid extraction
- Glass lined reactors, 500 to 5400 L for solid–liquid and liquid–liquid extractions

Chromatography
- GRACE bench scale preparative chromatography unit
- Columns up to 500 L for batch chromatography

Drying
- Continuous sludge dryer, 5 kg/h
- Vacuum tray dryer, 150 L filling volume
- Conical dryer, 980 L (ATEX)
- Filter dryer, 1900 L (ATEX)
- Drying oven, 2000 L
- Access to freeze- and spray drying facilities
- Spray dryer, 3 kg/h water evaporation
- Lyophilizer, 15 kg water per drying cycle

Various
- Multipurpose process tanks up to 8000 L
- Storage and process buffer tanks up to 50 m³
- Homogenizer, cell disruptor, 10 L/h

What we offer:
- Expertise in development, scale-up and demonstration of product recovery and purification processes
- A broad range of processing equipment for aqueous and solvent based applications
- Flexibility in setting up dedicated process lines
- …

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