BIOMASS PRETREATMENT

Equipment overview:

Reactors for chemical pretreatment of biomass:
These jacketed and agitated pressure reactors are suitable for acid, alkaline, solvent-based and chemical pretreatment. The reactors have temperature and pressure control and are coupled to a vacuum system for the evaporation of solvents.
- Benchtop 0.5, 2, 5 L (jacketed, agitated reactors)
- 1 x 20 L (ATEX, Hastelloy, pressure 0.060–10 bara, up to 160°C)
- 1 x 85 L (ATEX, stainless steel, pressure 0.050–9 bara, up to 165°C)
- 1 x 250 L (ATEX, stainless steel, pressure 0.050–7 bara, up to 100°C)
- 1 x 500 L (ATEX, glass lined, pressure 0.050–9 bara, up to 180°C)
- 1 x 1000 L (ATEX, glass lined, pressure 0.050–5.4 bara, up to 165°C)
- 1 x 5400 L (ATEX, glass lined, pressure 0.050–5.4 bara, up to 165°C)

Reactors for enzymatic hydrolysis of biomass:
These jacketed and agitated atmospheric reactors are suitable for aqueous, temperature-controlled reactions.
- Benchtop reactors 0.5, 2, 5 L
- Multiple reactors in the range of 20 – 1000 L
- Reaction vessels for slurries with high solids contents: 2 x 500 L
- 2 x 4000 L
- 2 x 5000 L
- 4 x 8000 L
- 2 x 14500 L
- 1 x 20000 L
- 4 x 24000 L
- 3 x 50000 L (insulated, not jacketed)

Auxiliary equipment:
- **Milling**
  - Dry milling: biomass cutter, ball mill (bench unit)
  - Wet milling: pulper (2000 L), inline mixer, inline colloid mixer
  - Lab sonicator (batch, 1-250 mL) and pilot sonicator (continuous, 1000 L/day)
- **Thermal treatment**
  - Direct steam injection, jet cooker with holding tubes (4 x 50 L, max. 150 °C)
  - Heat exchangers for indirect heating

Dewatering and concentration equipment
- Netsch filter press [cake volume 68 L]
- Schenck filter press [cake volume 120 L]
- Welders filter press [cake volume 352 L]
- Welders ATEX filter press [cake volume 100 L]
- Alfa Laval decanter centrifuge (3140 g, max 2500 L/h)
- Alfa Laval decanter centrifuge (3160 g, max 20 m³/h)
- Flottweg Sedicanter S3E (10000 g, max. 2500 L/h)
- Screw press
- Falling film three-effect evaporator, 5 t/h water evaporation
- Wiped film evaporator 250 kg/h water evaporation
- Chemical reactors for batch evaporation (20 L, 85 L, 250 L, 500 L, 1000 L, 5400 L)

What we offer:
- Mechanical, thermal, physicochemical, and enzymatic pre-treatment 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
  - Refrigerated storage rooms, freeze and cool containers
  - Warehouse at ambient temperature with a storage capacity of 200 pallets
  - Cool room at 4°C with a storage capacity of 130 pallets.
- A wide spectrum of modular operation units
- Operation at various scales

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, fibre, stems, leaves, verge grass...
- Lignocellulosic crops: miscanthus, wood, wheat straw, bark...
EXPERTISE

BIOMASS PRETREATMENT

BIOCATALYSIS

FERMENTATION

GREEN CHEMISTRY

PRODUCT RECOVERY AND PURIFICATION

ANALYTICAL CAPABILITIES

BIOCATALYSIS
BIOCATALYSIS

Equipment overview:

Process vessels for aqueous reactions:
- Bench-scale reactors
- Multiple mobile reactors in the range of 20 – 1000 L
- Aerated reactors (see fermentation folder)
- Reaction vessels for slurries with high solids contents: 2 x 500 L
  - 2 x 4000 L
  - 2 x 5000 L
  - 4 x 8000 L
  - 2 x 14500 L
  - 1 x 20000 L
  - 4 x 24000 L
  - 3 x 50000 L

Process vessels for solvent-based reactions:
- 1 x 20 L (ATEX)
- 1 x 85 L (ATEX)
- 1 x 250 L (ATEX)
- 1 x 500 L (ATEX)
- 1 x 1000 L (ATEX)
- 1 x 5400 L (ATEX)

Auxiliary equipment:
- Fermenters of different sizes to produce the biocatalyst (see fermentation folder)
- Enzyme purification equipment: cross-flow membrane filtration [MF, UF, NF in different scales ranging from bench to 10000 L scale, see product recovery and purification folder).
- A variety of downstream purification equipment to purify the product of interest from the reaction mixture (see product recovery and purification brochure)
- 4 x 30000 L (ATEX, solvent)

What we offer:

- Scale-up and demonstration of biocatalytic processes, using purified enzyme and whole-cell biocatalysts
- Bioconversion processes (see fermentation folder)
- Process development and optimization
- Food grade production (FSSC22000)
- First series compound production and custom manufacturing at 15000 L scale
- Immobilization of enzymes and whole cells
- Aqueous and solvent-based reactions
- Production of enzymes through bacterial, yeast, or fungal fermentation
- Process design

Expertise:

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

For more information: please visit www.bbeu.org
For questions, please call +32 9 335 70 01 or contact BusDev@bbeu.org
EXPERTISE

BIOMASS PRETREATMENT  FERMENTATION  BIOCATALYSIS  GREEN CHEMISTRY  PRODUCT RECOVERY AND PURIFICATION  ANALYTICAL CAPABILITIES

FERMENTATION

Bio Base Europe Pilot Plant
FERMENTATION

Equipment overview:

**(An)Aerobic fermenters:**
Batch, fed-batch, continuous
All fermenters have: six-blade (hollow blade) Rushton impellers, high aeration, baffles and optionally foam breakers, the stainless steel reactors can be pressurized (max 1.4 barg)

- 4 x 250 mL glass fermenters with a central control system for parallel operation
- 4 x 1 L stainless steel [gas] fermenters, max 10 barg
- 4 x 2 L glass fermenters with a central control system for parallel operation
- 4 x 3.6 L glass fermenters with a central control system for parallel operation
- 4 x 7 L glass fermenters
- 2 x 10 L glass fermenters
- 10 x 150 L stainless steel fermenters
- 2 x 1500 L stainless steel fermenters
- 2 x 15000 L stainless steel fermenters

**Anaerobic batch fermenters:**
- 1 x 20 L (ATEX)
- 1 x 85 L (ATEX)
- 1 x 500 L (ATEX)
- 1 x 1000 L (ATEX)
- 1 x 5400 L (ATEX)

**Gas fermenters, feed CO, CO\(_2\), H\(_2\), CH\(_4\):**
- 4 x 1 L [10 bar pressure]
- 1 x 10 L [ATEX, 5 bar pressure]
- Containerized mobile gas fermentation 10 + 100 L demo unit [under construction]

**Auxiliary equipment:**
- Analytical capabilities: HPLC, GC, GC-MS, fast biochemistry analyzer [YSI], [mass spec] off-gas analysis and data logging
- 2 x 12000 L feed tanks for the 1500 L and 15000 L fermenters
- Media preparation room
- Methanol [or ethanol] feeding to bench scale, 150 L, 1 x 1500 L and 1 x 15000 L fermenters
- In situ product recovery [ISPR]
- Nitrogen inertisation and blanketing
- Equipment for biomass separation: centrifuges, decanter, plate filters, filter presses, membrane filtration equipment [see product recovery and purification folder]
- A variety of downstream processing equipment to recover and purify the product of interest from the fermentation broth [see product recovery and purification folder]
- Production of 2G fermentable sugars [see biomass pretreatment folder]
- Cooling of the fermenters with cooling water from cooling tower and chiller
- Cell culture lab

**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
- Food grade production (FSSC22000)
- Optional: methanol [ethanol] dosage on every scale
- Process development and optimization
- First series compound production & custom manufacturing at 15000 L scale
- Examples of products: industrial enzymes, fine and bulk chemicals, biofuels, biochemicals, bioplastics, biosurfactants, biosolvents, nutraceuticals, food ingredients, bioflavours, proteins...

**Expertise:**
BBEPP has more than 10 years of experience in optimizing, scaling and transferring your fermentation protocol from the lab to commercial production. We count on an entire team of well-trained and highly motivated fermentation experts both with academic and industrial backgrounds to take your process to the next level!

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EXPERTISE

GREEN CHEMISTRY

BIOMASS PRETREATMENT  BIOCATALYSIS  FERMENTATION  GREEN CHEMISTRY  PRODUCT RECOVERY AND PURIFICATION  ANALYTICAL CAPABILITIES
GREEN CHEMISTRY

Equipment overview:

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

Reactor volumes (ATEX):
- 1 x 20 L (ATEX, Hastelloy, pressure 0.060–10 bara, up to 160°C)
- 1 x 85 L (ATEX, stainless steel, pressure 0.050–9 bara, up to 165°C)
- 1 x 250 L (ATEX, stainless steel, pressure 0.050–7 bara, up to 100°C)
- 1 x 500 L (ATEX, glass lined, pressure 0.050–9 bara, up to 180°C)
- 1 x 1000 L (ATEX, glass lined, pressure 0.050–5.4 bara, up to 165°C)
- 1 x 5400 L (ATEX, glass lined, pressure 0.050–5.4 bara, up to 165°C)

Auxiliary equipment (ATEX):
- Disc stack centrifuge: liquid-liquid or 3 phase separator, ca. 12000 g, max. 2.5 m³/h
- Filter dryer 1900 L for solvent extraction, [pre-coat] filtration and solids drying
- Chamber filter press: cake vol. 100 L, max. 7.7 m² filtration area, cake squeezing
- Karr column (ca. 6 L/h) for counter current liquid-liquid extraction
- Dead-end plate and frame filters
- Bag filters
- Columns for ion exchange, adsorption chromatography or activated carbon treatment (see product recovery and purification folder)

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
- Nitrogen inertisation and blanketing

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

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 scale.

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
EXPERTISE
PRODUCT RECOVERY AND PURIFICATION

The equipment overview below gives an idea of the variety of modular unit operations 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:

High speed disc stack centrifuges [60 L/h to 3 m³/h]:
- Solid-liquid separators (ca. 7000 g)
  1. GEA: max. 60 L/h
  2. Alfa Laval: max. 100 L/h
  3. GEA: max. 500 L/h, Alfa Laval: max. 3 m³/h
  4. Nozzle centrifuge: max. 3 m³/h
- Liquid-liquid or 3 phase separator (ca. 12000 g)
  5. GEA: ATEX, ca. 1 m³/h

Decanter centrifuges:
- Alfa Laval: max. 500 L/h (ca. 3000 g)
- Alfa Laval: max. 3 m³/h (ca. 3000 g)
- Flottweg Sedicanter: max. 2,5 M³/h (ca. 10000 g)

Basket centrifuges for crystal separation:
- Pilot unit: 10 kg, 1850 rpm
- Pilot unit: 40 kg, 1700 rpm
- Heinkel inverting filter centrifuge: 52 L, 1940 rpm

Cross flow membrane filtration (MF, UF, NF):
- Flat sheet pilot unit: testing of several membranes in parallel, max. 2 m²
- Multi-functional bench filtration unit (ca. 0.3 m²):
  - spiral wound, ceramic, hollow fibre (MF, UF, NF)
- Spiral wound filtration (MF, UF, NF)
  1. NF, RO Bench scale unit: ca. 0.23 m²
  2. MF, UF unit: single 3.8-inch membrane unit, max. 5.7 m²
  3. MF, UF unit: twelve 3.8-inch membranes, max. 70 m²
  4. MF, UF unit: nine 6.3-inch membranes, max. 5 bar, max. 150 m²
  5. MF, UF, NF, RO unit: two 8-inch membranes, max. 40 bar, max 45 m²
  6. MF, UF, NF, RO unit: six 8-inch membranes, max. 40 bar, max 180 m²
- Ceramic filtration
  1. MF, UF bench scale unit: max. 0.032 m²
  2. MF, UF single unit for 1 or 3 membranes: 0.2 or 0.6 m²
  3. MF, UF pilot unit: 55 membranes x 0.2 m² = 11 m²
  4. MF, UF pilot unit: 110 membranes x 0.2 m² = 22 m²
  5. MF industrial unit (0.5 µm): 288 m²
- Hollow fiber filtration (MF, UF)
  1. MF, UF bench scale unit: 0.037 m²
  2. MF, UF pilot unit: 10 and 500 kDa, max. 12.4 m²
  3. MF, UF pilot unit: 150 kDa, max. 50 m²

Dead-end filtration:
- Chamber filter presses:
  1. Bench scale unit: cake volume 1.44 L, max. 822 cm² filtration area
  2. Pilot unit: cake volume 68 L, max. 2.5 m² filtration area
  3. Pilot unit: cake volume 120 L, max. 6.5 m² filtration area
  4. Large pilot unit: cake volume 352 L, max. 35 m² filtration area, cake squeezing
  5. Large pilot unit ATEX: cake vol. 100 L, max. 7.7 m² filtration area, cake squeezing
Filter dryer 1900 L for solvent extraction, (pre-coat) filtration and solids drying
Plate and frame units with cardboard filters
Candle filters
Rotary vacuum drum filter RVDF (3 m²)
See “Basket centrifuges for crystal separation”

Ion exchange and adsorption:
Columns for ion exchange, adsorption chromatography or activated carbon treatment
- Bench-scale glass columns: 300 mL
- Glass columns: 3 x 5 L resin, max. 1 bar
- Fiberglass columns: 3 x 30 L resin, max. 16 bar
- Fiberglass columns: 4 x 300 L; 4 x 1 m³; 1 x 1.3 m³; 4 x 1.9 m³; 2 x 3 m³ resin, max. 10 bar

Crystallization:
- Benchtop reactors 500 mL and 2 L for cooling and/or evaporation crystallization
- Various reactors from 20 L to 5.4 m³ (several ATEX) for cooling and/or evaporation crystallization
- Continuous cooling crystallization unit 50 L
- Crystallization line up to 1000 t/y equipped with crystallizer 4 m³, inverting filter basket centrifuge, rotary louvre dryer

Evaporation:
- Wiped film evaporator, up to 250 kg/h
- Spinning cone evaporator, up to 50 kg/h
- Falling film three-effect evaporator, 5 t/h
- Batch evaporation reactors for batch evaporation of water and organic solvents and condensation for solvent recuperation

Evaporation:
- Wiped film evaporator, up to 250 kg/h
- Spinning cone evaporator, up to 50 kg/h
- Falling film three-effect evaporator, 5 t/h
- Batch evaporation reactors for batch evaporation of water and organic solvents and condensation for solvent recuperation

Extraction ATEX:
- Filter dryer 1900 L for solid-liquid solvent extraction, (pre-coat) filtration and solids drying
- Karr column (6 L/h) for counter current liquid-liquid extraction
- Glass lined reactors, 500 L, 1000 L and 5400 L for solid-liquid and liquid-liquid extractions
- Phase separation with disc stack centrifuge, max. 2.5 m³/h
- Vibrating sieve (sieve decks of 100, 400 and 1000 µm)
- Single-screw expeller press, max. 25 kg/h

Drying:
- Louvre crystal dryer ca. 4 kg/h water evaporation
- Vacuum tray dryer, 300 L filling volume
- Filter dryer, 1900 L (ATEX)
- Drying oven, 2000 L
- GEA Spray dryer, ca. 15 kg/h water evaporation
- Lyophilizer, 8 kg water evaporation per drying cycle
- Access to external freeze- and spray drying facilities

Various:
- Multipurpose temperature-controlled process tanks up to 24000 L
- Bench-scale preparative chromatography unit (GRACE)
- Storage and process buffer tanks up to 50 m³
- Solvent tanks ATEX 4 x 30 m³
- High-pressure homogenizer, cell disruptor (GEA, 10 L/h, max 1200 bar)
- High-pressure homogenizer, cell disruptor (APV, 850 L/h, max 1200 bar)
- Ball mill (bench unit)
- Access to a wide range of rental equipment
- Cleanroom with a metal detector for detection of ferro, non-ferro and stainless steel contamination in packaged powders (450 mm width x 250 mm height).
- Lab sonicator (batch, 1-250 mL) and pilot sonicator (continuous, 1000 L/day)
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 custom process lines
- Food grade production (FSSC22000)
- Warehouse at ambient temperature with a storage capacity of 200 pallets
- Cool room at 4°C with a storage capacity of 130 pallets.

Expertise:

BBEPP has more than 10 years of experience in purifying various metabolites from fermentation processes, as well as in purification of products from biomass via biorefinery or biocatalytic processes. The experienced team helps our customers to develop and scale their purification process from lab to commercial scale.

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EXPERTISE

BIOMASS PRETREATMENT      BIOCATALYSIS      FERMENTATION      GREEN CHEMISTRY      PRODUCT RECOVERY AND PURIFICATION

ANALYTICAL CAPABILITIES
ANALYTICAL CAPABILITIES

Equipment overview:

Process follow-up for the quantification of sugars, organic acids, intermediates, compounds of interest and enzyme activity
- 5 Agilent HPLCs with following detectors: DAD, RID, VWD and ELSD
- Dionex HPLC with ED electrochemical detector
- GC coupled to mass spectrometry
- GC with FID
- YSI biochemistry analyzer
- Colorimetric using Agilent and Tecan (micro plate reader) spectrophotometers

Off-gas analysis systems
- Off-gas MS analysis
- Mobile BlueSense off-gas analysis
- Mobile micro-GC

Evaluation of physico-chemical properties and moisture content
- Light microscopes
- Digital dino-lite crystal microscope
- Easy KFV Karl Fischer titration
- [Portable] Turbidimeters
- Sartorius moisture analyzers
- Brookfield Viscometer
- Thermogravimetric analyzer
- Conductivity, pH and brix meters
- ...

What we offer:

- A dedicated team of analytical experts to implement your method of choice and to optimize methods to allow fast analysis
- A wide range of analytical methods available for quantification of various compounds
- Process control through close analytical follow-up of compounds of interest

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