

Maria Cuellar Soares, on behalf of the BPF

The Bioprocess Pilot Facility to a bio-based economy

Maria Cuellar Soares



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Many developments in the production of chemicals, materials and fuels from renewable materials are currently being made on laboratory scale. But in order to reach industrial implementation novel processes and technologies need to be tested and demonstrated at a relevant scale. Given the complexity, the costs and the risks associated with scale-up research, CSM/Purac, DSM and Delft University of Technology decided to join forces in the Bioprocess Pilot Facility BV: a state-of-the-art 5000 m² facility for industrial biotechnology. The BPF is financially supported by the European Union, the Dutch Ministry of Economic Affairs, Agriculture and Innovation, the Province of South Holland and the Municipalities of Rotterdam, Delft and The Hague. It officially opened on May 15th 2012 and it is ready to operate.

The BPF is an independent BV and an open access facility, meaning that in addition to the partners other enterprises and institutes can make use of its facilities. The possibilities are broad: think of SME's that need to prove their developed technology first at a realistic scale before selling it or license it to others, industrial biotech companies that want to test alternative feedstocks for their running processes, equipment developers that want their prototypes to be tested by experts with actual production materials, researchers that need to evaluate the effect of scale on process performance and so on. Several goals can be met whether the interest lies in obtaining technical data at process or equipment level, or whether it lies in obtaining sufficient product for further application tests.

Modular and flexible

The BPF has been designed for flexibility. This means that every step can be executed independently from the other steps and that every step can be both a starting point (input) and an end point (output). The facilities are distributed in the following sections (see Figure 1).

Pretreatment
Alternative feedstocks that do not compete with food such as agri-

cultural and forestry waste can be used for the production of chemicals and fuels by fermentation. Such feedstocks, also referred to as lignocellulosic feedstocks, mainly contain cellulose, hemicellulose and lignin. In the pretreatment section, the lignocellulosic feedstock is processed into a solution of fermentable sugars, namely pentoses and hexoses. Depending on the feedstock, an initial mechanical size reduction step is required in order to facilitate handling and to increase the surface area for subsequent steps. The biomass is then treated with steam under high temperature and/or pressure, for example. In this way, the bonds within cellulose, hemicellulose and lignin are broken, the hemicellulose is (partly) hydrolyzed and the cellulose is released for further (enzymatic) hydrolysis.

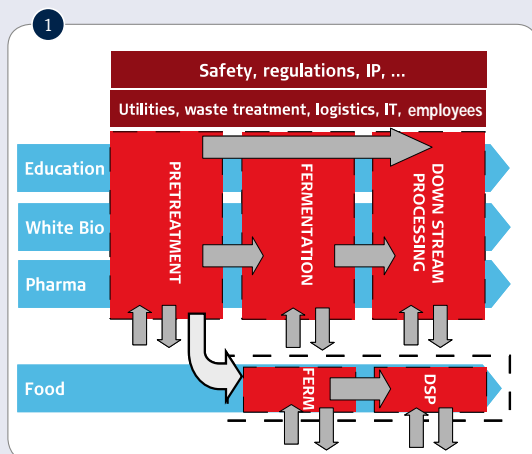
Fermentation

The fermentable sugars obtained after pretreatment, or other feedstocks obtained externally, are processed using micro-organisms such as bacteria, yeast and moulds in fermentors up to 8 m³ scale. The fermentations can be performed in batch, fed-batch or continuous mode, under aerobic or anaerobic conditions. Depending on the process and the micro-organism, the product is either accumulated inside the cells or secreted to the fermentation medium. The fermentation section includes all facilities for medium preparation and sterilization, inoculum preparation, main fermentation and primary recovery.

Downstream processing (DSP)

The fermentation broth is further processed in order to recover and purify the product. Given its modular

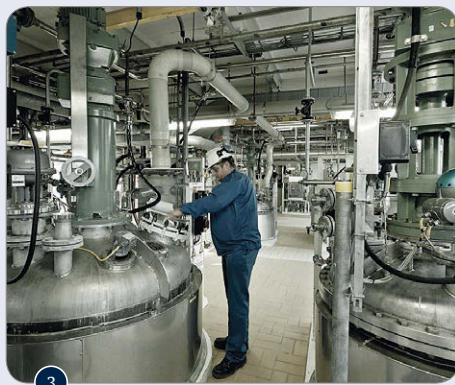
Scope of the BPF



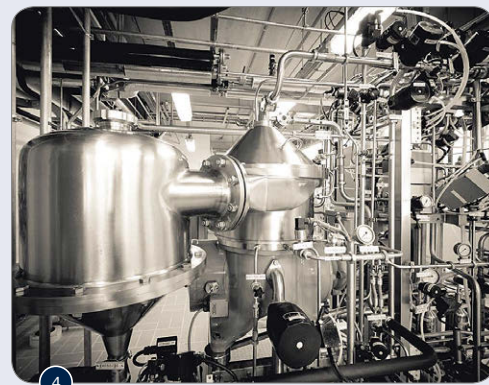
(BPF): enabling the transition



Medium scale fermentation facilities



Facilities for downstream processing (reaction vessels in the foreground)



Facilities for primary recovery

setting, the DSP train can be built as required. Typical processing steps include cell disruption (for intracellular products), solid/liquid separation, (bio)chemical conversion, concentration, purification and drying. For each processing step several unit operations are available such as filtration, centrifugation, extraction, evaporation, column chromatography and crystallization.

The BPF can accommodate processes for the production of (bulk) chemicals and biofuels, and for the food and pharmaceutical industries. Their different sanitation requirements result in zones and separate production areas. Nevertheless, the facility has the capacity for running more than one process in parallel and for serving more than one client at the time. Confidentiality and IP protection have a prominent place in the operation of the facility.

Bioprocess integration

An integrated approach on bioprocess development is critical for speeding up industrial implementation. This view has been incorporated in the BPF design at different levels:

- In the process, by aligning the capacities of the different sections so that, despite the modularity and flexibility of the facility, it is also possible to run a complete process from feedstock receipt and pretreatment to product recovery and purification.
- In the buildings, by allowing for efficient transport of materials, equipment and people between the different sections.
- In the equipment, by enabling the implementation of integration concepts such as (by-)product removal during fermentation (also known as ISPR or in-situ product removal).

Especially important is the investment in human capital and know-how. The current staff of the BPF has a vast

experience in the scale up of industrial biotechnology processes. But next to this, the BPF has a commitment to become a centre of expertise, providing education and training at different levels.

The BPF now and what's coming up

The facility has started with the pilot plants already existing on the site of DSM in Delft. Those pilot plants were originally built for scale-up research on the industrial biotechnology processes from DSM. During the last years they were also used for contract manufacturing to external parties. The pilot plants were brought in by DSM, as one of the consortium partners, into the joint venture. With these facilities it is already possible to perform scale-up research including parts of the pretreatment (e.g. hydrolysis), fermentations up to 4 m³ in stirred fermentors and most DSP processing steps. However, many bottlenecks in the transition to lignocellulosic feedstocks lie in the pretreatment: depending on the feedstock and process conditions, degradation compounds are formed that are toxic for the subsequent hydrolysis and fermentation steps. Additionally, the composition and properties of the feedstock (e.g. viscosity, presence of slurries) will have an impact on fermentor and DSP performance. Because of this, current investments are mostly directed to the broadening of pretreatment line (for both bench and pilot scale) and of the fermentation facilities with an 8 m³ bubble column fermentor, planned to be implemented in the coming 12 to 18 months. Additional investments are projected on specific unit operations for DSP, data acquisition and automation packages and civil engineering, among others. Furthermore, its links to research programs such as BE-Basic (www.be-basic.org) will keep the facility up to date with the developments in industrial biotechnology. ●