

## BIOPROCESS MODULE 2

# Fermentation

In the Fermentation module, bioconversions are processed by means of micro-organisms (bacteria, yeasts or fungi) or enzymes to obtain the desired product.



### Fermentation

The Fermentation Pilot Plant is equipped with 100 l, 300 l, 1 m<sup>3</sup> and 4 m<sup>3</sup> vessels which can be used for batch or fed-batch processes. The 300 l and 4 m<sup>3</sup> fermentors have dedicated feeding capabilities. Mixing is applied by speed controlled Rushton turbine stirrers. Dissolved oxygen levels in aerated processes are controlled by computer models. All ingoing and outgoing flows are measured and logged in the process computer. In the near future an 8 m<sup>3</sup> bubble column fermentor can handle batch or fed-batch type fermentations.

### Sterilization

The vessels are sterilized by means of steam. Heat-sensitive substances can be sterilized using filters; undesired reactions between substances during (heat) sterilization can be avoided by separate treatment in portable vessels in our autoclaves.

### Inoculum

Shake flasks and aerated small steel vessels (10 l) provide inoculum for the inoculum vessels and fermentors in the plant by direct sterile connection. Fermentors of 100 l and 1 m<sup>3</sup> can also be used as inoculum vessels. A fully automated transfer panel provides biomass from the inoculum vessels to the fermentors.



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### 10 liter

Four stand-alone 10 l lab fermentors\* are intended for initial fermentation tests on a small scale and for fermentation tests of feedstocks that have been treated in the bench scale pretreatment unit. The in situ sterilizable fermentors have jackets and Rushton type agitators with speed control, similar to the large main fermentors.



### 100 liter

The four 100 l vessels are often used as inoculum vessels for multiple 300 l and 4 m<sup>3</sup> fermentors, but can also be used for executing batch processes. Maximum filling is 70 kg depending on hold-up. Auxiliary substances can be added from extra vessels.

### 300 liter

The four 300 l vessels can be used for executing batch and fed-batch processes. Maximum filling is 180 kg depending on hold-up. Each vessel is equipped with two dedicated feed vessels. Auxiliary substances can be added from additional vessels. The 300 l fermentors are located in the ATEX (T3) zone.

\* Available in 2014

# Fermentation



### 1 m<sup>3</sup>

One 1 m<sup>3</sup> vessel is often used as inoculum vessel for the 300 l and 4 m<sup>3</sup> fermentors, but can also be used for executing batch processes. Maximum filling is 750 kg depending on hold-up. Auxiliary substances can be added from additional vessels.



### 4 m<sup>3</sup>

One 4 m<sup>3</sup> vessel can be used for executing batch and fed-batch processes. Maximum filling is 2,800 kg depending on hold-up. The vessel is equipped with two dedicated feed vessels. One additional vessel is in place for auxiliary substances. The 4 m<sup>3</sup> fermentor is located in the ATEX (T3) zone. This scale can also be used for small production batches or production trials. Fermentation usually is followed up by our DSP section.

### 8 m<sup>3</sup> bubble column

The 8 m<sup>3</sup> fermentor\* can handle a batch or fed-batch type fermentation with an operational volume of approximately 6 m<sup>3</sup>. Agitation is accomplished by bubbling a gas of choice through the column. The bubble column is located in the ATEX (T3) zone.

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### Centrifugation

The Fermentation Pilot Plant is equipped with a disc centrifuge, which can handle the broth of the 4 m<sup>3</sup> fermentor and the 8 m<sup>3</sup> bubble column. The centrifuge is located in the ATEX zone.

### Utilities

Standard chemicals for pH-control are 98% sulphuric acid, 25% sodium hydroxide and 25% ammonia. All vessels have anti-foam dosing possibilities for hold-up control and a spare vessel is available for dosing of various chemicals when required (for instance pH-control by means of a titrant other than our standard titrants).

### ATEX

Flammable materials can be used in the designated ATEX zones (T3) of the Fermentation Pilot Plant, including in the 4 × 300 l and the 4 m<sup>3</sup> fermentors and, in the future, the 8 m<sup>3</sup> bubble column.

### Analyses

Standard analysis is performed on fermentation experiments like biomass concentrations in broth (filtration, centrifugation and OD), pH and contamination. In process analysis of substrates or products can be executed, like glucose, ethanol, organic acids and precursors by means of a biochemistry analyser and HPLC. Standard measurements are performed by a mass spectrometer for off gas analysis.



### Safety, Health and Environment

The scaling up of laboratory experiments often comes with safety issues, like handling larger amounts of raw materials, dealing with permits of the micro-organism (broth >100 l), handling large amounts of flammable and/or toxic chemicals, transport and/or storage of broth or end products, and, finally, disposing of waste materials. Therefore, every new experiment is preceded by a safety study.

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