Basic knowledge

Biological processes and reactors

Generally, a lot of different processes exist in process engineering. Each process is based on agents such as organisms, cells or enzymes. The respective agents are selected based the desired products and starting substances. The knowledge which agents are suitable for which application comes from basic disciplines like biology, biochemistry, etc. The knowledge which ambient conditions are ideal for the agents in order to guarantee a high quality and quantity of the products also comes from these disciplines. The respective production process is developed based on this information. The individual steps are similar for many processes and their sequence.

Basic process steps

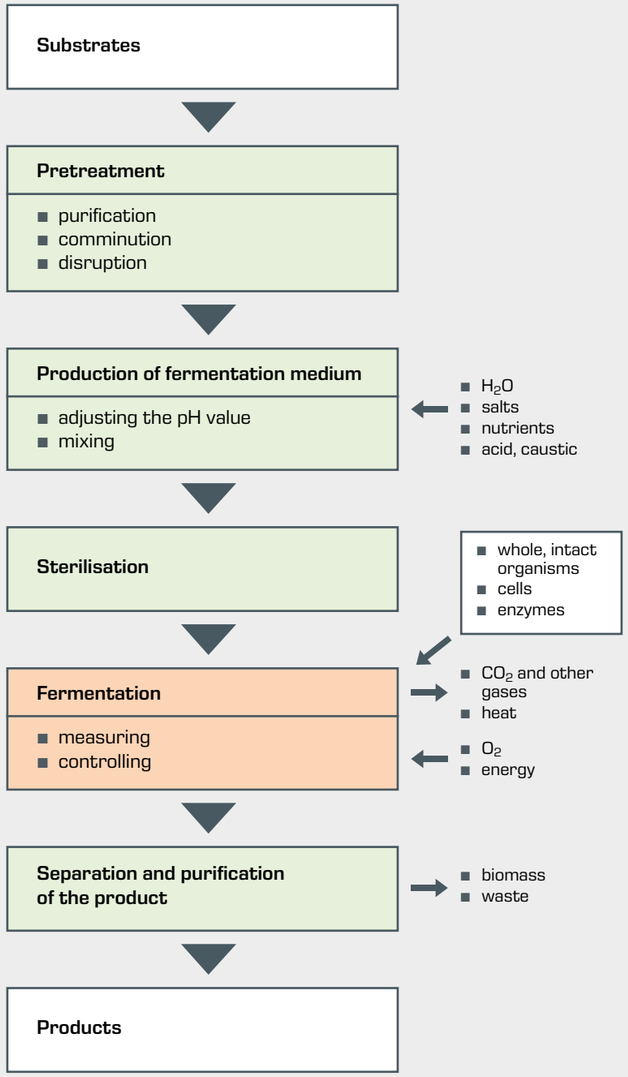
The starting substances are also called substrates. They can be pure substances such as sugar or alcohol. Often these substances first have to be gained from substrates such as molasses, spent mash, etc. and made available for the biological agents, for example by comminution.

Water, salts and nutrients are then added to achieve the best fermentation medium for the agents. The pH value often plays an important role in this process.

Many biological processes require the specific exclusion of foreign bacteria to hinder competing microorganisms and reactions. This means that the fermentation medium and the reactor have to be sterilised.

The actual production process (fermentation) takes place in the reactor, where agents such as organisms, cells and enzymes convert the starting substances to products. The reactor has to be exactly adjusted to the respective agents. In aerobic processes, for example, even distribution of oxygen in all areas is very important. Controlling the temperature by applying or dissipating heat is also important.

The fermentation medium leaving the reactor is a complex mixture in which the product is diluted or still in the form of cells. The solids are correspondingly separated by means of filtration, centrifugation or sedimentation. The cells are opened, for example, by mechanical force or osmotic pressure. Methods such as extraction, adsorption or precipitation are used for concentrating and purifying.



General schematic sequence of biological processes

Bioreactors

The bioreactor is the core element of a biotechnical production facility. One of its main tasks is optimal mixing of the reactor contents to guarantee frequent contact of the nutrients and biological agents. In addition, it is important that the interface formed between the gaseous phase and the liquid is as large as possible. In aerobic processes, oxygen is transported to the biological agents. In anaerobic methods, the quick removal of gases such as methane must be ensured. A general distinction is made between surface reactors and submerged reactors.

Surface reactors

The biological agents adhere to the surface of liquid or solid substances as a biofilm. In aerobic processes, the oxygen comes directly from the gaseous phase bordering on the biofilm.

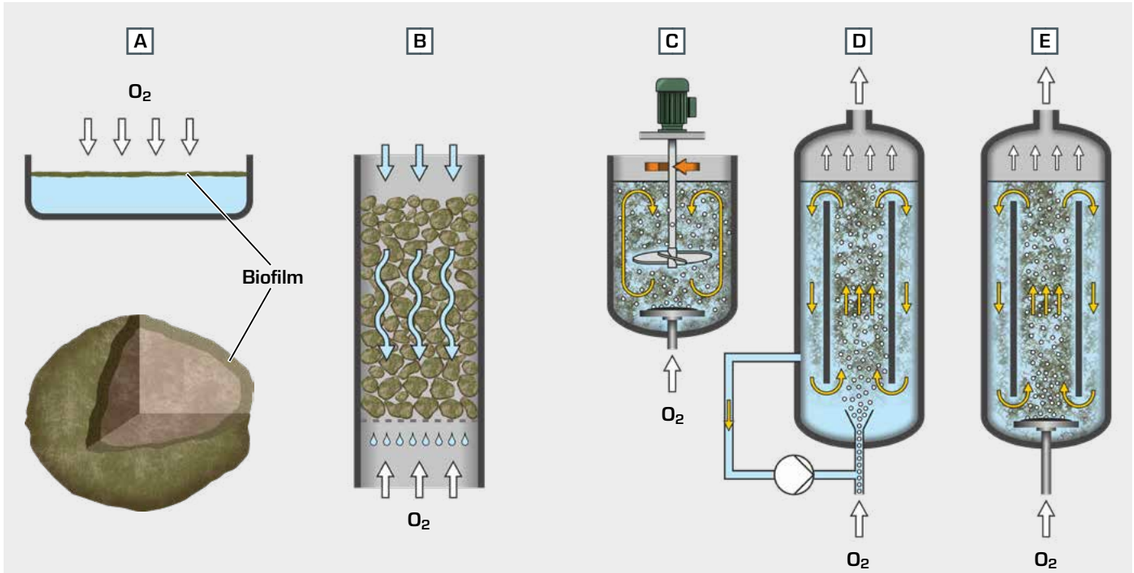
The simplest process is the **static surface culture (A)**. In this process, a biofilm floats on the surface of a liquid substrate in a shallow dish, where it is supplied with nutrients from below and oxygen from above.

In bed reactors, the biofilm is fixed on a solid surface. In fluidised bed reactors, the solid can move freely in the liquid. In **fixed bed reactors (B)**, the solid does not move. The liquid substrate trickles through the fixed bed from above. In aerobic reactors, the oxygen is supplied from below.

Submerged reactors

In contrast to surface reactors, the interface between the gaseous phase and the liquid must be maintained in submerged reactors by dispersing the gas in the liquid. For this purpose, energy must be continuously applied to the process. The energy can be applied in three ways:

- **Energy application by means of stirrers**
  In aerobic processes, compressed air is fed into the **stirred tank reactor (C)**. A stirrer ensures fine dispersion of the air bubbles and distribution of the nutrients. High shear forces and the destruction of microorganisms can be a disadvantage.
- **Energy application by means of a fluid pump**
  A pump recirculates the entire reactor contents through an external loop. There are several variants which differ by the location of the liquid intake and supply. In **jet reactors (D)**, the pump generates a propulsion jet which ensures recirculation in the reactor.
- **Energy application by means of gas**
  The air bubbles themselves ensure recirculation of the reactor contents due to a density difference. The recirculation may take place inside or outside the reactor. In **airlift reactors (E)**, guiding devices ensure internal recirculation. Airlift reactors have lower shear forces and consume less energy than stirred tank reactors.



Surface reactors (aerobic):

A static surface culture, **B** fixed bed reactor

Submerged reactors (aerobic):

C stirred tank reactor, **D** jet reactor, **E** airlift reactor