Application of membrane techniques in food processing and biotechnology

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Membrane filtration processes allow the separation of dissolved organic molecules, anorganic salts as well as desalted water from a liquid stream, which was normally aqueous. But they can also be carried out with organic solvents. A liquid stream is separated into the concentrate (retentate) and the permeate. Higher molecular weight compounds remain in the concentrate and are circulated in the case of batch processes during low molecular weight compounds are discharged together with the solvent (typically water) as the permeate.

With respect to increasing molar mass cut-off, membrane filtration processes are distinguished into reverse osmosis, nano-, ultra- and microfiltration.

These four processes and also electrodialysis are well established methods in food processing and biotechnology. They can be used for desalting, concentration, purification and separation of products. The separation characteristics depends on the molecular weight, molecular geometry and the polarity of the molecules.

The mean pore diameter of the membranes vary from approx.0.3 nm (reverse osmosis) up to 20 000 nm (microfiltration) and allow in aqueous systems the separation of water and salts or organic molecules with molar masses in the range of 10^2 g/mol (e.g. lactic acid) up to 10^7 g/mol (e.g. starch) as well as viruses, bacteria and particles.

In industrial practice four different types of moduls are available:

1. Tubular moduls with tubes having an inner diameter between 4-25 mm
2. Hollow fiber modules having fibers with an internal diameter of less than 1.3 mm
3. Flat moduls
4. Spiral wound moduls

A lot of different polymeric materials e.g. cellulose acetate, polysulfone, polyester, polycarbonate, polyamide, polyimide, polyvinylidenfluoride, polytetrafluoroethylen, polyvinyl chloride, polypropylene etc. are used for the manufacturing of membranes. Ceramic membranes or carbon tubes are also available.

Membrane filtration processes can be carried in batch operation or continuously. Also the diafiltration process, the washing out of low molecular weight components, is suitable for purification of high molecular weight components in the retentate. In addition, it´s possible to operate membrane filtration plants as bioreactors and separate continuously enzymatically degraded organic compounds into the permeate.

The transmembrane pressure drop during reverse osmosis, nanofiltration and ultrafiltration is about 50, 15 and 3 bar, respectively, due to the various differences of the osmotic pressures in retentate and permeate in this three processes.

In nano- and ultrafiltration processes, the most important parameter, the permeation rate, is influenced by a lot of parameters like retentate properties, membrane surface polarity, molar cutt off, temperature, pH-value, transmembrane pressure drop, viscosity, Reynolds number (laminar-turbulent), membrane fouling, concentration polarization etc..