Membranes in their many configurations are used throughout the food processing industry. They offer a number of advantages over more traditional filtration methods, such as pressure filtration with diatomateous earth, or cartridge or bag filters. With the help of Bruce Butchermaker of Ionics Inc, Filtration+Separation explores why it makes sense to use membrane separation processes in a wide variety of food production processes, ranging from dairy to fruit juice.

Membrane technology benefits the food processing industry

Membranes in a variety of configurations, including tubular, hollow fibre and spirally wound have been used in the food industry for many many years. They can be applied within the production process, i.e. for clarification and concentration, as well as used to treat the resulting wastewater prior to disposal (sewer or surface discharge) or re-use.

The main benefits of membrane are well documented and fall into two main categories (a) *improved production process*, i.e.

- Consistent high quality of permeate/retentate
- Reduced operating costs
- Low maintenance
- Low pressure drop
- Chemical and temperature resistance
- Long membrane operating life

and (b) *recovery of valuable products* that previously would have been lost to waste.

Traditonal filtration methods

Food manufacturers have traditionally met their requirements for solid/liquid separation by using diatomaceous earth (DE) , such as rotary vacuum filtration employing DE to separate gelatin. In more recent years, however, it has become clear that the use of DE results in a number of problems. These include:

- Health and environmental concerns regarding dust exposure - inhalation of crystalline silica has been linked to silicosis and the National Institute of Occupational Safety and Health (NIOSH) has labelled DE as a potential carcinogen.
- Loss of product in disposed filter cake.

Membranes can offer a number of advantages to food processors.

- Issues related to the disposal of spent cake to landfill - ever more stringent legislation is being introduced to govern this.
- Regular process inefficiencies, including upsets and stream breakthroughs, leading to product loss/re-processing costs.

In contrast, the use of membrane technology overcomes these problems, particularly from the the health and safety, and the disposal point of view.

Another example of the benefit of using membranes is in the clarification of fruit juice. Traditionally, cartridge or bag filters are used, but they operate in a dead-end filtration mode, which generates a lot of media waste that needs to be disposed of. Membranes, on the other hand, operate in a crossflow mode, so there is less build-up on the surface of the membrane, and therefore media disposal problems are minimized.

Membrane processes

Below we present examples of membrane processes commonly used in the food processing industry and their applications within this industry.

(i) Microfiltration (MF)

In the food processing industry MF is commonly used for clarification instead of centrifugation and for sterilization in place of heat. It is primarily used to remove suspended solids (SS), fat and high molecular weight (HMW) proteins.

In the diary industry, for example, it can be used to clarify cheese whey, as well as de-fat and reduce the microbial load of milk. However in the latter case, to counteract large variations in transmembrane pressure the MF system may have to utilize constant pressure filtration, in which the permeate is pumped co-currently with the feed on the opposite side of the membrane. This will result in a constant pressure driving force, leading to improved flux and better rejection performance.

(ii) Ultrafiltration (UF)

UF is ideal for fractionation, concentration and purification. For example, UF can be used to fractionate milk for cheese production, i.e. the retentate contains proteins, fat and certain insoluble and bound salts, while the permeate contains lactose and soluble salts. A particularly large market for UF is in the specialty milk-based beverages, e.g. UF concentration of skimmed milk produces a product that has a high calcium and protein content.

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Another industry where UF has found popularity is the fruit juice industry, where the permeate rather than the retentate is the product of interest. Here, UF can be used to clarify a wide variety of fruit juices by removing impurities, such as yeast, moulds, bacteria and colloids, together with proteins, tannins and polysaccharides, which all helps to impart stability to the final product.

(iii) Nanofiltration (NF)

NF is most commonly used to separate a solution that has a mixture of some desirable components and some that are not desirable. An example of this is the concentration of corn syrup. The membrane will allow the water to pass through the membrane while holding back the sugar, and therefore concentrating the solution. In addition to sugar, NF is capable of concentrating divalent salts, bacteria, proteins and other constituents that have a molecular weight greater than 1000 daltons.

NF can be used to partially demineralization, as well as concentration. In the dairy industry, for example, NF is a relatively new process for the demineralization of whey. However, it has been shown to be able to obtain a degree of desalination of 40%, which converts the whey into a valuable by-product - during the cheese-making process whey is made worthless through the addition of salt.

(iv) Reverse osmosis (RO)

RO is used in food processing to concentrate, purify and recover valuable components, either alone or in combination with other membrane separation processes, such as MF and UF.

One of the main advantage of using RO is the reduction in the costs associated with evaporation, or even the elimination of this step. The energy requirements of RO have been shown to be significantly less than for mechnical vapour compression. RO's other advantages include:

- High quality product separation without heat damage
- Reduced waste treatment volume, and therefore costs
- Relatively small footprint and lower capital requirements

However, balanced against these are a number of drawbacks, including limited operating pressure range in particular applications and membrane fouling with certain feed sticks.

(v) Electrodialysis (ED)

ED is used to demineralize milk and whey, de-acidfy fruit juices and de-ash sugar solutions, such as dextrose. In these applications, ED is often competing with ion exchange (IEX), but the continuous process operation of ED makes it is more economical.

An evolution of ED is electrodeionization (EDI). It is best described as a combination of ED and IEX, and functions in a similar way to ED, but allows deionization to a much lower level EDI is a relatively new process to the food industry.

Membrane benefits

The benefits of switching to membrane filtration can be demonstrated in the processing of cheese whey. Thirty years ago whey was seen as a waste product from the cheese-making process and was duly disposed of, either being dumped in the river or spread on the land, or in a few cases used as animal feed.

RO technology can be used to produce waters, with a consistent ratio of desired minerals to enhance the flavour of various foods.

However, membrane filtration has changed all that, e.g. by using ED, a processor can produce infant formula, while the application of UF will concentrate the proteins that can then be used in commercial protein drinks and bars.

Membrane advances

In more recent times there has been a move away from spirally wound polymeric membranes towards ceramic membranes (either in a tubular or monolithic configuration). Ceramic membranes despite being more expensive in the short term (although in most cases they do become more cost effective in the long term), do have a number of advantages over polymeric membranes.

They include being physically more durable, which means the membrane can be cleaned with highly caustic solutions, can withstand high temperatures (particularly important in the food industry as most processes operate at temperatures above which bacteria can grow) and can be steam-sterilized. They also offer longer life cycles.

Finally, an emerging membrane technology for the food industry is bipolar ED, which operate by splitting water into H^+ and OH^-, and therefore converting salts into acids and bases. The technology has been designed to replace IEX because it does not have the disposal problems associated with the regeneration chemicals. However, at the moment this technology is not commonly used in food processing, except in the production of vitamin C, but that may well change in the near future.

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