Eco-efficiency for Australian dairy processors

Fact sheet 10: Membranes

Membranes are commonly used within the dairy industry for the recovery of product, chemicals or water. A major advantage of membrane separation technology is that the separated substances can be recovered in a chemically unchanged form.

Types of membrane separation technology commonly used in the dairy industry are microfiltration (MF), ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO). They are used to:

- pre-concentrate milk and whey proteins
- improve cheese yields and product consistency
- produce whey protein concentrate and valuable by-products
- fractionate whey and lactose intermediates
- recover and reuse of permeate waste and brine
- recycle spent caustic and acid solutions
- control microbial growth and extend the shelf life of dairy products.

Membranes are typically 'cross-flow', where two streams are produced — a 'permeate' and a concentrated 'retentate'. Table 1 shows the relative pore sizes of membranes and their typical application in dairy processing. In reality, the boundaries between MF, UF, NF and RO membranes are not uniform, as performance specifications vary from supplier to supplier.

Membrane technology can be costly, so it is essential to have a clear understanding of current costs regarding waste disposal and the financial value of recovering product, water or chemicals. It is important to know the quality requirements of the recovered substances and the characteristics of the feed stream, as well as the conditions under which the membrane will have to operate (pressure, temperature, pH and chemicals); this will also help to ensure that the type and configuration of the membrane suits the application. Cleaning membranes when flow rates drop, to remove fouling, can help improve the membrane's effectiveness; however, it may also reduce the membrane's finite life. It is usually beneficial to pre-treat the feed stream to remove solids.

Membrane plant

Table 1: Membrane use in the dairy industry

Membrane type	Molecular weight	Approximate pore size (μm)	Application in dairy industry
Microfiltration	>100 000–3 000 000	0.01–4.0	• Dextrose clarification • Bacteria removal
Ultrafiltration	10 000–150 000	0.005–0.1	• Protein, whey, milk concentration • Clarification • Standardisation of protein
Nanofiltration	150–20 000	0.0008-0.009	• Lactose rejection • Protein, whey, milk concentration • Recovery of caustic from CIP
Reverse osmosis	<300	0.0001–0.002	• Whey, milk, lactose concentration • Polishing RO permeate • De-ashing whey, lactose • Clarification • Desalinisation of salty whey

The following describes some membrane technology applications:

Ultrafiltration (UF) and reverse osmosis (RO)

About 90% of the milk used for making cheese ends up as whey — a watery waste containing valuable proteins and sugars. Whey protein and lactose can be recovered and sold, while the water recovered can be used for cleaning the membrane units and as boiler feedwater. UF is used to produce the whey protein concentrate, and the permeate is fed directly to RO, which produces water suitable for reuse. Membrane filtration cannot be used to recover resources for all products and waste streams. For example, water recovered from whey permeates by reverse osmosis should not be used in cheese factories because of the risk of bacteriophage, a virus that disrupts the cell membranes of bacteria used in the cheese-making process.

Ultrafiltration plant to recover milk permeate

Warrnambool Cheese and Butter in Allansford recovers milk permeate from a UF plant to standardise milk powder. Almost 100% of the milk permeate is utilised for standardising and any excess permeate is sold to other dairy companies. A major challenge was setting up the standardising equation in the control system to ensure that the quantity of permeate used did not reduce the protein levels below specification. The payback period was 8 months.

Membranes used for chemical recovery

Reverse osmosis (RO)

Some dairy processing plants use RO to polish evaporator condensate. The permeate is generally used for boiler or cooling tower water make-up, because additional treatment is necessary to make permeate of potable quality. A current barrier to using membrane filtration for treating condensate water for reuse is the cost of treatment compared with the cost of using fresh town water. For example, it is estimated that the cost of treatment for one Victorian plant is around 90c/kL whereas the cost of town water is 69 c/kL.

Water recovery using membranes

Murray Goulburn in Rochester processes around 800 kL/day of whey to produce whey powder and lactose powder. Whey is processed in ultrafiltration, nanofiltration and reverse osmosis (RO) plants. The plant permeate from the RO plant is recycled back to the factory as usable water. Over a year the RO plant saves 70 000 kL ($32 000) in reduced water intake.

Nanofiltration (NF)

Nanofiltration is commonly used in CIP systems to recover chemicals, with the potential to recover as much as 99% of cleaning solution, most often caustic. The retentate, which contains highly concentrated nitrogen and fatty compounds, is treated as a sludge.[1]

Upgrade of detergent recovery system

Bonlac in Cobden upgraded their detergent recovery processing to double the capacity. The initiative led to annual savings of $83 000, with a payback period of 2.3 years.

1 Daufin et al., Recent and emerging applications of membrane processes in the food and dairy industry, *Trans IChemE*, **79**(C2): 89-102. 2001.

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For further information see the *Eco-efficiency for the Dairy Processing Industry Manual*, August 2004 or contact the UNEP Working Group for Cleaner Production: phone 07 3365 1432, email p.prasad@uq.edu.au
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