

Ultrafiltration in potable water production

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Abstract

A low-pressure membrane technology for the one-step clarification and disinfection of water for potable use is described. The membranes are operated at net driving pressures of between 30 and 40kPa. The filtered product of low turbidity was produced continuously and there was no correlation between the turbidity of the feed and that of the product. The membrane process appears to be an effective means for filtering out coliforms, to render a good quality potable water upstream of final breakpoint chlorination.

Introduction

Ultrafiltration is a pressure-driven membrane filtration operation by which submicron species are removed from water. Low- to medium-molecular mass cut-off ultrafiltration membranes not only reduce microbial counts in water but, because the pores in the membrane skin-layer are in the 10 to 50 nm size range, the membranes readily remove components that contribute to colour and turbidity in such waters. Ultrafiltration can be applied equally well, *inter alia*, to the production of potable water (Cheryan, 1986) from contaminated sources, as to the clarification and sterilisation of wine (Wang et al., 1989).

Ultrafiltration membranes have an asymmetric substructure and are generally produced from polymeric materials by a phase-inversion process (Aptel et al., 1985). During this process a homogeneous polymer solution is transformed into two liquid phases, one of which is a polymer-rich phase and the other a solvent-rich or polymer-poor phase. The polymer-rich phase coagulates during the liquid-liquid phase-separation process to form the membrane matrix, whereas the polymer-poor phase forms the interconnecting porous mass that eventually merges into the skin-layer of the membrane to create pores in the nanometre size range. The skin-layer of these integrally skinned asymmetric membranes is the most dense, while the remaining substructure becomes gradually more open-porous with increasing distance away from the skin-layer. Ultrafiltration membranes are surface filters and not depth filters; the characteristics of the skin-layer of the membrane, to a large degree, therefore define the retention properties of the membrane.

Membrane flux

The skin-sections of ultrafiltration membranes have pores or openings in the nanometre size-range, which allow transport of water under a hydrostatic driving force. Figure 1 shows the cross-section of an ultrafiltration membrane and a typical example of the asymmetric nature of the substructure of an integrally skinned membrane.

Poiseuille's law describes solvent flow (J) or product flux through the (assumed cylindrical) pores in the skin section of a membrane:

$$T = \frac{NT_d^4 AP}{128Axu}$$

where:

- N = number of pores per unit area
- AP = applied hydrodynamic pressure
- Ax = pore length (including a tortuosity factor)
- u = solvent viscosity
- \bar{d}_p = pore dia. (average)
- J = product flow

The equation shows clearly that the product flux is directly proportional to the applied pressure, porosity and the fourth power of the pore dia., and inversely proportional to the thickness of the membrane film and viscosity of a given permeating fluid.

It is evident from the equation that the product flux of a membrane with a certain fixed pore size and rated molecular mass cut-off can be increased by reducing the thickness of the membrane skin-layer (i.e., by reducing the resistance of the membrane to transport), or by increasing the number of pores in the skin-layer. However, the molecular mass cut-off performance (retention performance) of the membrane will be lowered if the pore-size of the membrane is enlarged to increase the product flux.

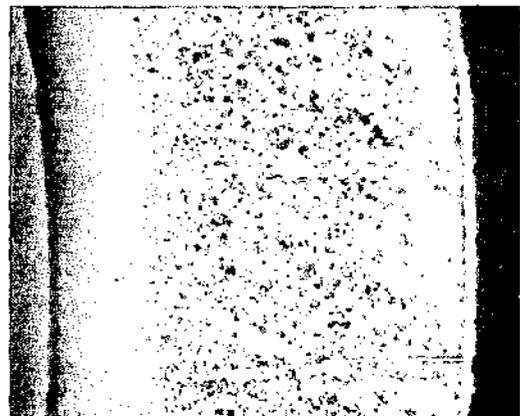


Figure 1
Typical cross-section of an ultrafiltration membrane

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