

Membrane performance restoration. I: Abattoir process streams, cleaning regimes for UF membranes

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Abstract

Ultrafiltration offers attractive advantages in the treatment of effluent streams originating from an abattoir. However, severe fouling caused by the presence of proteinaceous and fatty constituents in such streams reduce membrane transport rates to unacceptable levels in a very short period. Cleaning regimes by which membrane transport rates can be restored and maintained effectively have been evaluated both in the laboratory and applied in the field with success.

Introduction

Most commercial ultrafiltration (UF) membranes are manufactured from hydrophobic polymer materials as these materials are chemically, physically and mechanically more robust than their hydrophilic counterparts. Although the chemical resistance and mechanical properties of these membranes allow them to be used under sometimes harsh and hostile conditions, their hydrophobic properties can often be the cause of drastic loss of flux due to fouling.

As a unit operation of separation, UF offers some attractive advantages with respect to reducing the chemical oxygen demand (90%) and phosphate loads (85%) of wash and process water effluent streams that originate from abattoirs (Cowan et al., 1991). However, these streams contain numerous proteinaceous, fatty and other constituents, and when such an effluent is treated by UF membranes, fouling of the membranes and a loss of product flux are inevitable (Binnie and Partners, 1988a; 1988b).

Certain pretreatment steps such as screening and air flotation to remove fat and other bulky materials are a minimum requirement in such a strategy, as these operations reduce the solids load in the feed and the rate of fouling to some extent. However, fats and proteins readily pass these initial pretreatment operations, so that their potential to foul membranes remains unchanged (Hartmann, 1991).

It is therefore unwise to operate hydrophobic polysulphone or poly(ether sulphone) UF membranes on abattoir effluent streams without the use of some strategy by which the original pure-water flux of the membranes can be secured.

Animal fats (lipids) are one constituent of an abattoir effluent which can cause severe fouling of hydrophobic UF membranes. Fats give rise to particular problems because of their low solubility in water and their hydrophobic nature (membrane adsorption potential).

Proteins, another major constituent in the effluent stream are macromolecular substances that are fibrous or globular in shape, but completely loses this conformation when denatured. They consist mostly or sometimes entirely of polypeptide molecules which are co-polymers of sets of 20 different α -amino acids which may have polar or non-polar residues or ionisable groups.

Proteins that contain many charged groups can, for example, be precipitated by changing the ionic strength or organic solvent content of the solution. Precipitation of protein and/or adsorption of substances (Lips and Jessup, 1979) greatly affects the performance of a membrane (Ostrovskii et al., 1990).

The only non-specific method that will ensure total solubilisation and subsequent removal of proteinaceous precipitates, for example, is to degrade the protein into smaller peptides or amino acid monomers. The peptide bond in all proteins is quite stable, and complete hydrolysis of all these bonds in nature is accomplished with the aid of a group of very specialised molecules called proteases or proteolytic enzymes. These proteinous catalysts specifically break the peptide bonds to yield shorter peptides and ultimately amino acid monomers.

This paper describes a different approach to securing effective cleaning agents for UF membranes operating on an abattoir process effluent. In this study, industrial materials, proved by the abattoir industry to be effective cleaning and sanitising agents, were evaluated first in the laboratory and then in the field for their ability to restore the pure-water flux (PWF) productivity of UF membranes. Also of importance was to determine to what extent these materials might be harmful to the membranes.

Experimental

Materials

Ultrafiltration membranes

In the laboratory studies, a 2,4 m module with 719-series 13 mm diameter tubular poly(ether sulphone) UF membranes, that had been operating in a pilot plant on effluent from the Cato Ridge Abattoir in Natal, was obtained through Membratex. The module had been operated under adverse conditions and the membranes were severely fouled.

Cleaning agents

The experiments that were conducted to determine the effectiveness of cleaning materials, centered on the use of 2 commercial products, one a proteolytic enzyme-based formulation (used in conjunction with sequestering, wetting and emulsifying agents, all specially formulated for use in the abattoir industry), and the other a mild chloralkali sanitiser.

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