

The use of dynamic membranes for the treatment of effluents arising from wool scouring and textile dyeing effluents*

RB Townsend¹, FG Neytzell-de Wilde¹, CA Buckley^{1**}, DWF Turpie² and C Steenkamp²

¹Pollution Research Group, Department of Chemical Engineering, University of Natal, King George V Avenue, Durban 4001, South Africa

²Gubb and lngs Ltd., PO Box 23, Uitenhage 6320, South Africa

Abstract

Dynamic membrane technology has been extensively researched, with particular reference to industrial effluent treatment. Two major plants have been commissioned in the wool scouring and textile dyeing industries.

The results of the operation of these plants have shown that product water of a reusable quality was produced. In the case of wool scouring effluent, an average flux of 37 l/m²-h could be maintained under correct operating conditions. Recent trials on the treatment of rinse liquor from a wool processing plant has shown that an average flux of 80 l/m²-h can be maintained, provided that the membranes are reformed on an approximately two-weekly cycle. An average flux of 33 l/m²-h was obtained from the dye effluent treatment.

Introduction

Membrane separation techniques have been developed over a number of years for desalination purposes, and, more recently, for the treatment of a variety of industrial effluents for pollution abatement and water reuse.

Industrial effluents often contain a wide range of chemicals including acids, bases, organic chemicals, colloidal material and suspended solids. Incompatibility of the membrane with the chemical nature, temperature, and solids content of the effluent often limit the selection of the membranes available and may make the use of extensive pretreatment of the effluent essential and expensive.

The use of dynamic or formed-in-place membranes may overcome many of these problem areas. The advantages of a dynamic membrane include the following:

- long service life of the support tube;
- ability to be operated at high pressure and temperature;
- in cases of severe fouling, the membrane can be removed by chemical means and re-formed *in situ*; and
- pretreatment to remove solids, whilst always desirable, is not critical in terms of mechanical damage to the membrane.

Formation of dynamic membranes

Dynamic membrane technology was pioneered by the Oak Ridge National Laboratory (Marcinkowsky et al., 1966 and Johnson et al., 1972). Research indicated that membranes of the hydrous zirconium (iv) oxide type were more suitable than many of the other hydrous oxides which were tested.

Zirconium type membranes are formed by the deposition of hydrous zirconium (iv) oxide onto the porous structure of a suitable support from colloidal suspensions. Stringently controlled conditions are necessary for the formation of high performance membranes.

Since stable zirconium chelate complexes form with many organic compounds by co-ordination through oxygen atoms, this

enables the deposition of certain polymers onto the hydrous zirconium (iv) oxide membrane layer. This in turn then leads to the possibility of tailoring a membrane for specific duties. The most commonly used polymers for this purpose are of the polyacrylic acid type.

The methods of formation are described in detail by Johnson et al. (1972). It has been proposed by Freilich and Tanny (1978) and Tanny and Johnson (1978) that when a dilute colloidal suspension of hydrous zirconium (iv) oxide, at a pH just below 4, is passed across the surface of a porous substrate, the first stage involves a pore filling, or bridging stage, where colloidal particles of hydrous zirconium (iv) oxide are captured on the walls of the porous support material. This process causes the pores to close after a period and is followed by a surface filtration cake from colloidal particles, as commonly occurs in other types of cross-flow microfiltration. This then represents the hydrous zirconium (iv) oxide membrane which, in acidic solutions, is an anion exchanger.

When a polyelectrolyte, such as polyacrylic acid, is then passed over the hydrous zirconium (iv) oxide, the electrolyte enters the pores of the membrane rather than forming a gel layer on the surface. It is also suggested that at low pH values, the polyelectrolyte molecules are hypercoiled and easily able to penetrate and react with the substrate. If the pH is then raised, the polyelectrolyte molecules expand to block the pores, thereby causing a rapid decrease in flux and increase in rejection. This then represents the composite (Zr/PAA) membrane, which, in a neutral to alkaline solution, has the properties of a cation exchanger.

The hydrous zirconium (iv) oxide membranes are characterised by high water fluxes (150 l/m²-h-MPa) whilst showing a significant salt rejection (40 %). The composite Zr/PAA membranes have lower water fluxes (30 l/m²-h-MPa) but significantly higher salt rejection capabilities (85 %). Actual values will depend on the substrate and formation conditions of either the zirconium (iv) membrane or the composite membranes.

To distinguish these membranes from conventional phase inversion membrane films prepared by casting or other procedures, the class is designated dynamically formed or dynamic. More recently these membranes have been referred to as "formed-in-place" membranes.

Most of the early research was conducted using porous carbon or ceramic support tubes but problems with the robustness of the

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** To whom all correspondence should be addressed.

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