

## Membrane Technology for Gas Separations

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### ABSTRACT

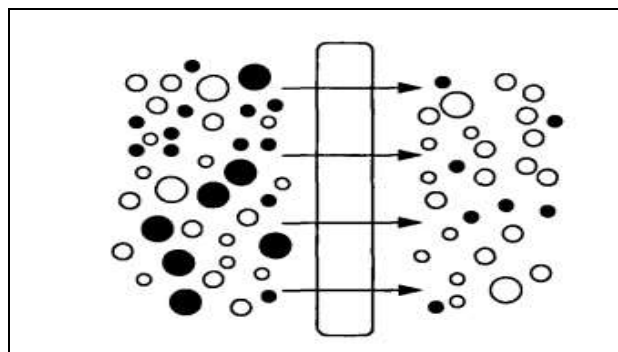
Membrane defines as the barrier. Membrane used to filter the gaseous. Membranes can take many forms, from porous and non-porous solids to liquid phase membranes and gels. Currently, most industrial processes are based on polymeric materials. These are either micro porous, with pores typically up to 20 A, or dense with no discernible pores. This paper reviews the membrane properties and model.

**Keywords:** Liquid phase membrane, non porous, polymeric materials

### INTRODUCTION:

These are either micro porous, with pores typically up to 20 A, or dense with no discernible pores. Molecules are driven across a membrane when subjected to a gradient in chemical or electrical potential. This is often the result of a concentration or pressure difference between the two phases. Selection of the correct membrane is imperative as both the speed and nature

of this transport are functions of membrane structure. The speed of transfer also depends upon the physical properties of the permeating material such as its molecular size. Thus the introduction of a membrane between two phases permits the selective transfer of components and thereby facilitates their separation, Figure 1,[1].



**Fig. 1:** Molecular transport through a membrane.

### MEMBRANE SEPARATION TECHNOLOGY

In most membrane separations, the feed stream is split into two product streams: The permeate and the retentive. The permeate is the material that has passed through the membrane and the retentive is

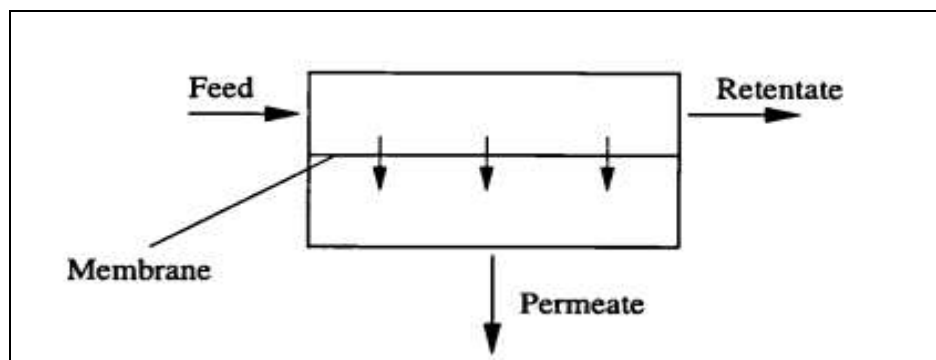
the material that has been rejected by the membrane. This is illustrated in Figure 2. Membrane technology can be applied to particle - liquid separation, liquid - liquid separation as well as gas separation. Each of these alternatives are now considered, and a summary is shown in Figure 3.

Particle - liquid separation the use of membranes for the separation of particles from liquids is now firmly established. In this field, there are several well developed categories in dialysis, micro solutes pass through a semi-permeable membrane when driven by a difference in concentration. The separation is achieved as smaller solutes diffuse through the membrane at a faster rate than larger macro solutes.

In electro dialysis, electrical potential is the driving force for mass transfer across the membrane rather than a concentration gradient. Reverse osmosis, or hyper filtration, differs from dialysis and electro dialysis in that the membrane selectively restricts the flow of solutes whilst allowing the flow of the solvent. The driving force for solvent transfer through the membrane is a pressure difference which must exceed the osmotic pressure of the solution. Large pressure differences (10 to 100 bars) are

usually required to overcome the high resistances of reverse osmosis membranes. It is generally considered that the main mechanism for solute transfer through the membrane is a concentration gradient. Reverse osmosis technology can be used for particles up to about  $3 \times 10^{-9}$  m in diameter, though for the larger particle sizes ( $1$  to  $3 \times 10^{-6}$  m) it is often referred to as nano filtration and ultra filtration used to filter the larger solvent.

The membranes used in ultra filtration are less dense than those used in reverse osmosis and so high fluxes can be achieved using much smaller pressure differences (typically 1 to 5 bar). Microfiltration is used to separate micron sized particles ( $1 \times 10^{-7}$  to  $3 \times 10^{-6}$  m) from a suspension; it is similar to both ultra filtration and conventional filtration. The resistance of microfiltration membranes is low and small pressure differences (0.1 to 2 bar) are usually sufficient [2,3].



*Fig. 2: Schematic representation of a simple membrane separation*

### **Liquid**

Liquid separation the constituents of a multi-component liquid feed will pass through a dense membrane when driven by a concentration gradient. The liquid - liquid separation sector divides neatly into two categories in evaporation, the membrane represents a barrier between the liquid (the feed) phase and a gaseous (permeate) phase.

The permeate is pulled off, either by a sweep gas or into a vacuum. In this

process, liquid molecules diffuse across the membrane and undergo a phase change referred to as perm selective evaporation. In order to provide the heat of evaporation, the enthalpy of the feed stream is reduced.

The resulting temperature drop can be large, particularly at the relatively high flux rates seen for concentrated systems. To compensate for this effect, interstate heaters are often employed between membrane modules. Per traction is different to evaporation in that the

permeating components desorbs into a purge or sweep liquid rather than into a gaseous phase so unlike evaporation, it is an isothermal process. However, fluxes are much lower and there are no current examples of industrial per traction (Ho and Sirkar, 1992). Gas separation Gas molecules are driven through the membrane when subjected to a partial

pressure difference. The gas that dissolves and passes through the membrane most quickly (the fast gas) is collected as permeate. In general, only dense membranes provide a high enough degree of separation, though in some cases micro porous membranes are used, such as in the separation of uranium isotopes [4,5].

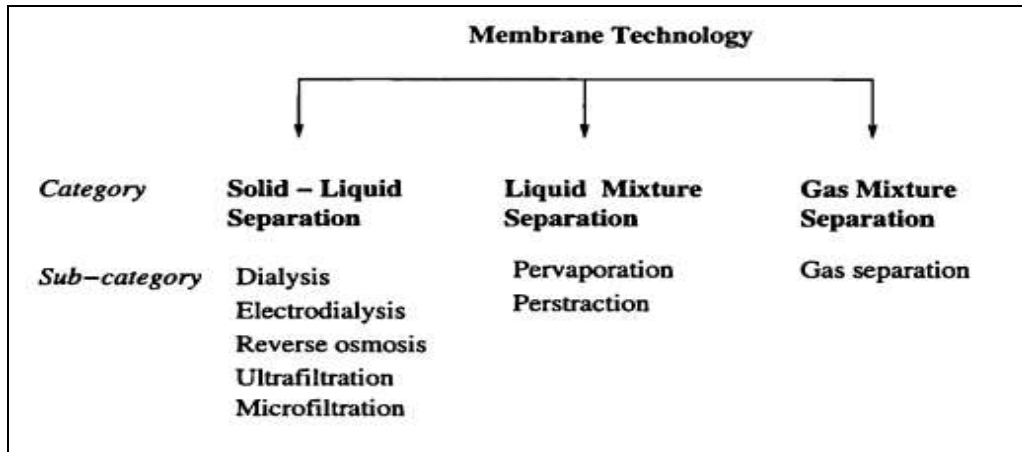


Fig. 3: Membrane separation technologies.

**GENERAL MEMBRANE MODELS**

Most of the mass transport models described previously suffer from non-constant parameters and are unable to predict some of the complex phenomena inherent to membrane separations (such as flux coupling). In response, attempts have been made to develop more theoretical models. There are two detailed approaches which incorporate a greater understanding of the nature of flux thorough a membrane: the dusty gas model and the frictional model. The models can be used to describe flux through both micro porous and dense membranes for all membrane separation processes. A third approach applied to a variety of membrane processes is to

characterize membrane performance using the thermodynamics of irreversible processes (e.g. Molina et al., 1997). Dusty gas model The dusty gas model has gradually been developed by Mason and co-workers (Mehta et al., 1976; Mason and Lonsdale, 1990) over a number of years from a statistical-mechanical approach. The original model first derived for gas systems has been developed further to describe a general separation using chemical potential as the driving force. The main feature of the model is that viscous and diffusion effects are considered separately. The dusty gas model for isothermal flux in the absence of external forces can be written

$$\sum_{j=1}^n \frac{(x_i J_j - x_j J_i)}{c_{\Sigma} D_{i,j}^D} - \frac{J_i}{c_{\Sigma} D_{im}^D} - \frac{\alpha_i^D B_0}{\mu D_{im}^D} \nabla P = \frac{x_i}{R'T} \nabla_{T,P} \psi_i + \frac{x_i}{c_{\Sigma} R'T} \nabla P \dots\dots[1]$$

Frictional model The Stefan-Maxwell equation (Kerkhof, 1996) equates frictional resistances to driving forces. According to the (Kerkhof, 1996) and Lightfoot (1974) equation written as

$$\sum_{j=1}^n \frac{(x_i J_j - x_j J_i)}{c_{\Sigma} D_{i,j}^F} - \frac{J_i}{c_{\Sigma} D_{im}^F} = \frac{x_i}{R'T} \nabla_{T,P} \psi_i + \frac{\phi_i}{c_{\Sigma} R'T} \nabla P \dots\dots[2]$$

The model parameters (DF') can either be interpreted as frictional resistances or as diffusion coefficients. The difference between the dusty gas and frictional models is in the approach to viscous effects. The dusty gas model incorporates an additional term to account for viscous flux. Mason and Lonsdale (1990) showed that the models are algebraically equivalent if the frictional coefficients are regarded as "augmented diffusion coefficients" incorporating viscous effects. In both cases, experimental data is still required, although some of the parameters can be predicted from standard diffusion and membrane data (Lawson and Lloyd, 1996).

Design of membrane separation systems in this section, the use of mathematical models for the design of membrane separation systems is considered. In the design of a general membrane separation plant, there are several factors to take into account, these include: the required membrane area; the module type and size; the process configuration; the positioning of additional equipment items such as heat exchangers and pumps; and the operating point of the plant (temperatures, pressures, etc.). Therefore, selecting the best design values involves many complicated and interacting choices.

- To consider each choice separately making use of existing experimental data, simulation results and known heuristics. Each choice can be reconsidered iteratively if initial solutions are deemed to be uneconomic. However, even with an iterative approach there is no guarantee that the best design is found because of

interacting, and often conflicting, decisions.

- The second type approach is over recent years, several authors have considered the use of optimization algorithms to do this. The main advantages of this method are that assumptions of the nature of the process are not required, and interacting decisions are fully taken into account if accurate models have been used. These works are now discussed.

### CONCLUSION

The low cost membrane technology is more feasible to gas separation. It is reducing the CO<sub>2</sub> and increase the methane contains.

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