

Ion-Exchange Membranes Using PVC as a Binder

Most of the ground waters available in the desert regions of Western Rajasthan, India, are brackish, and as such are not fit for drinking purposes. One of the possible methods of desalting such waters is electrodialysis. For this purpose the heterogeneous type of membranes based on parchmentized kraft paper developed by the South African Council for Scientific and Industrial Research¹ was considered useful since the methods of preparation of the membranes are simple and cheap. However, these membranes on preparation and use in laboratory scale models were found to be unsatisfactory as regards life and mechanical strength. Here it will be of interest to note that the plant installed at Welkom based on this method has now been shut down, one of the reasons being the difficulties encountered in reaching the original design considerations.² Alternate methods were, therefore, studied and as a result it was found that heterogeneous types of membranes with satisfactory characteristics could be prepared by binding the resin with an inert organic binder dissolved in a suitable solvent. Montecatini³ has used a similar method for the preparation of ion-exchange membranes based on rubber. Honey and Hardy⁴ have employed dimethylcyclohexanone to prepare a plastic dough containing PVC and the ion exchanger for obtaining the membrane by extrusion.

The ion-exchange resins employed here were a sulfonated polystyrene-based cation exchanger manufactured and marketed by M/s Tulsu Industries, Poona, India, under the trade name Tulsion 42, and DeAcidite FF, the anion exchanger manufactured by Permutit Co. PVC was used as the binder and was dissolved in either nitrobenzene or dioxane. The ion-exchange resins were finely ground in their wet form, dried at room temperature ($30 \pm 2^\circ\text{C}$.), and sieved to 200-mesh size. Preliminary studies with mixtures of these resins in a solution of PVC showed that for obtaining a membrane which does not crack or from which the resin particles peel off easily, the resin-to-PVC ratio should be 70:30. Keeping this in view, the powdered resins were separately added to required quantities of solution of PVC in nitrobenzene or dioxane at 60°C . and stirred well. Half the quantity of the resin mixture was poured over a level glass plate, the edges of which were raised with paraffin wax so as to retain the mixture. A thin nylon fabric was then spread over the film of liquid mixture on the glass plate, ensuring that no air bubbles are entrapped. The remaining quantity of the mixture was poured over it. It was allowed to dry at room temperature to the extent that the film could be peeled off from the glass plate easily. Normally, dioxane films dried in about 48 hr. and the nitrobenzene films in about 96 hr. The membranes on peeling off from the glass plate were put in water and allowed to swell. Wrinkles, if any, in the film were removed by tightly clamping the membranes between two stainless steel plates and heating in an oven at about 80°C . for 2 hr. Films of varying thicknesses were prepared using different quantities of the mixture.

The thickness, moisture retention, and shrinkage on drying of the membranes were determined as usual. The total ion-exchange capacity of the cation-exchange membrane was determined by converting it into the hydrogen form by treatment with 1N HCl, leaching until free from acid, adding excess of 10% NaCl solution, and titrating with standard alkali. The total anion-exchange capacity of the anion-exchange membrane was determined by converting it into chloride form by treatment with 1N HCl, leaching until free from acid, adding excess of 4% Na_2SO_4 solution and titration of the liberated chloride with standard silver nitrate solution as usual. The electrical resistance of the membranes was determined by the strip method.⁵ The transport number was determined according to the method of Kressman and Tye⁶ using 0.1N sodium chloride solution. The bursting strength was determined by the ASTM method⁷ using a steel ball of 1.000 in. diameter over a circular membrane area of 1.750 in. diameter using an electrically operated vertical load frame with a proving ring, the rate of traverse being 0.05 in./min. The results thus obtained for two typical membranes are shown in Table I.

TABLE I
Physical and Chemical Properties of Two Typical
Hydrated Ion-Exchange Membranes

Property	Cation-exchange membrane	Anion-exchange membrane
(1) Thickness, mm.		
(a) Wet (swollen)	0.86	1.16
(b) Dry	0.80	1.05
(2) Moisture content, %	30.1	34.5
(3) Shrinkage in linear dimension on drying, %	7.5	8.5
(4) Total exchange capacity, meq/dry gr.	2.1	1.3
(5) Conductivity, mhos/cm. ³	2.19×10^{-3}	0.87×10^{-3}
(6) Transport number ($t+$ for cation and $t-$ for anion)	0.95	0.95
(7) Bursting strength, lb./in. ²	18.5	18.5

Further studies are in progress with these membranes for desalting of brackish water.

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References

1. J. R. Wilson, *Demineralization by Electrodialysis*, Butterworths, London, 1960.
2. *Ind. Eng. Chem.*, **54**, No. 6, 34 (1962).
3. Montecatini, Ital. Pat. 529,967; *Chem. Abstr.*, **52**, 14900i (1958).
4. M. O. Honey and C. R. Hardy, U.S. Pat. 28,10,932; *Chem. Abstr.*, **52**, 3203h (1958).
5. J. R. Wilson, *Demineralization by Electrodialysis*, Butterworths, London, 1960, p. 209.
6. T. R. E. Kressman and F. L. Tye, *Discussions Faraday Soc.*, **21**, 185 (1956).
7. ASTM, D1117-59.

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