

NOTES

*Diffusion Effect During Electrodialysis
with Ion-Exchange Membranes**

Electrodialysis operation with synthetic ion-exchange membranes has been found efficient as long as the permselective property of the membranes is maintained. It is well known that as the external concentration of the electrolyte solution increases, the permselectivity decreases due to the transport of the coion and counterion resulting from Donnan diffusion.^{1,2} Besides this, another important aspect to be considered is the water transport due to the ion during its passage through the membrane. Experimental evaluation of the amount of water transported during electrodialysis of various salt solutions has shown that for the same concentration, the amount of water transported increases with the crystallographic ionic radius of the cation of the salt studied.³

Wilson⁴ has pointed out the practical significance of equations derived for electro-osmotic water transfer in electrodialysis. According to this, it is not possible either to concentrate or demineralize a solution of sodium chloride of 4.63 *N* (or 27% solution) by electro-osmosis. Tuwiner,⁵ considering efficiency of desalting with current efficiency, has shown that even with membranes of perfect selectivity, it will not be possible to concentrate sodium chloride solution of 27% concentration (or 4.63 *N*). This concentration range is, however, considered well outside the range of commercial electrodialysis.

In continuation of the investigations carried out earlier, it was of interest to study the water transport and desalting with solutions of sodium chloride of the following concentrations: 1.0 *N*, 1.5 *N*, 2.0 *N*, 3.0 *N*, and 4.6 *N*. The electrodialysis was carried out in a nine-chambered cell constructed with Permaplex C20 and A20 membranes, the technique adopted to read the excess volume of water collected in the concentrating chambers has been described earlier.⁶ The solutions collected from the desalting and concentrating chambers were analyzed, and the amount of salt removed at various influent concentrations has been plotted against the influent concentration in the figure. The curve obtained reveals that there is maximum electrodialysis at the 1.0 *N* level of sodium chloride and there is a gradual decrease in efficiency up to 2.0 *N* concentration (value for 0.5 *N* concentration obtained from earlier experiments). Until this stage, evidence for electrodialysis had been obtained by analyzing both the desalting and concentrating chamber solutions and determining the excess salt build up and excess water transported in the solution collected from concentrating chambers. It was observed that the water transport value was also normal (i.e. 11–12 moles of H₂O/g.-mole of salt). As the concentration was increased above 2.0 *N*, analysis of the concentrating chamber solution revealed little or no salt build up. However, there was evidence of water transport even though the volume was much lower than in the ranges 0.5–2.0 *N*. But as the salt build up was negligible, no data could be collected for water transport in terms of salt transported in this range.

However, analysis of the solution collected from the desalting chambers revealed a large decrease in salt content. This reduction is attributed to diffusion since no salt build up was noticed in the solution from the concentrating chambers. In our earlier publication,⁶ a detailed description of the set up of the cell has been presented. As described therein, the solution to be desalted enters the second chamber and after passage

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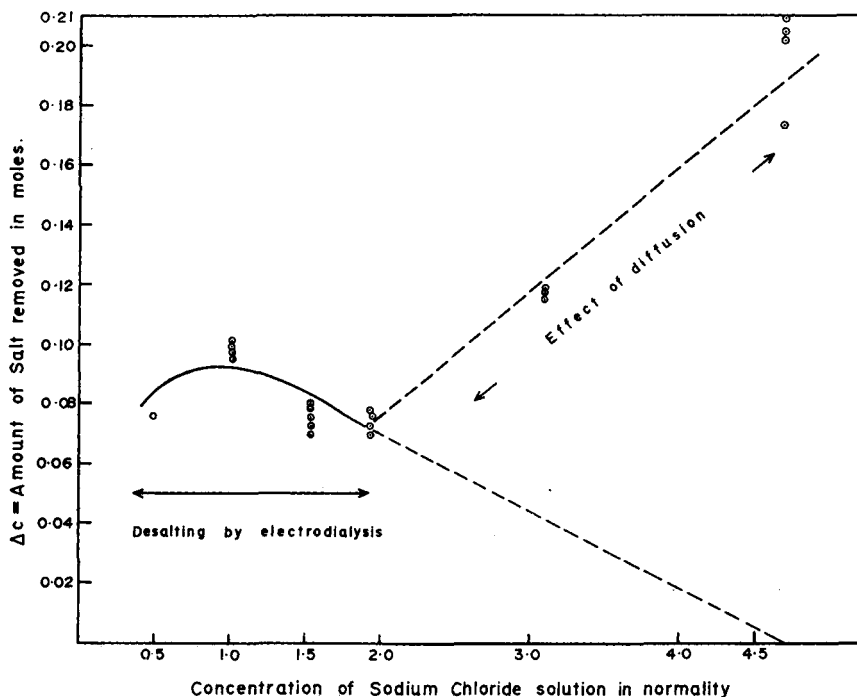


Fig. 1. Effect of diffusion during desalting highly concentrated sodium chloride solution.

through chambers four and six is collected from chamber eight. Chambers one and nine are the electrode chambers through which tap water (125 ppm. total solids) is passed. Thus, the two desalting chambers, numbers two and eight, are adjoining the electrode chambers containing the more dilute tap water, and diffusion of salt is possible. This has been actually verified by evaluating the solids content of the tap water collected from the electrode chambers, and this revealed increase in salt content. The concentrating chambers three, five, and seven are removed from the electrode chambers and effects due to diffusion are very little. Figure 1 presents the picture of gradual fall in electro dialysis as the concentration increases, and inflexion indicates rise in desalting due to diffusion effects.

Thus, with the experimental set up described, it has been possible to verify that at about 4.6 *N* concentration, it is not possible to concentrate or desalt sodium chloride solution by electro dialysis. Due to diffusion effects, salt reductions are observed in this range.

References

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