FLUORIDE REMOVAL AND RECOVERY FROM WATER USING REVERSE OSMOSIS AND OSMOTIC MEMBRANE CRYSTALLIZATION

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ABSTRACT**:** Fluoride becomes a matter of concern for human health when present at high concentrations. To address this, the World Health Organization (WHO) has established a guideline of 1.5 milligrams per liter for fluoride in drinking water. Nevertheless, fluoride also holds significant value as a compound with multiple applications. Consequently, the development of a system that enables the removal and recovery of this valuable element from water is of great interest. The aim of this study was to evaluate the performance of an integrated process consisting of reverse osmosis (RO) and membrane crystallization to remove fluoride from water and to recover it as a pure fluoride salt. To conduct RO experiments; the Armfield FT17 filtration system was employed. This lab-scale unit utilizes flat-sheet membranes and is designed for crossflow filtration with smaller product volumes. A commercial RO membrane known as TriSep X—20 was utilized. For osmotic membrane distillation and crystallization (OMD-Cr) setup a hollow fiber membrane contactor apparatus was employed. The RO experimental results show that; the contact angle of the commercial RO membrane was measured before and after filtration using an optical contact angle measuring and contour analysis system. Prior to filtration, the mean contact angle ranged from 10.1° to 15.8°, whereas after filtration, it ranged from 27.2° to 58.9°. the study also showed that the optimal transmembrane pressure strongly depends on the feed concentrations. The maximum pure water permeability of the commercial membrane was found to be 4.8 ± 0.1 $Lh^{-1} bar^{-1} m^{-2}$ at 40 bar. The rejection rate varied between 92.5 and 98.6. Concerning the OMD-Cr experiment result; the effect of the feed concentration on the transmembrane water flux was evaluated. The findings indicated that at lower feed concentrations the flux was not significantly influenced. However, at higher feed concentrations the transmembrane water flux was significantly influenced by the concentration. On the other hand, the concentration of the osmotic solution showed a very significant effect on both the transmembrane flux and the mass transfer coefficient due to the water activity dependence on concentration being higher. Finally, pure sodium fluoride crystals with octahedral structure and a face-centered cubic crystal system were obtained, with an average size of 160.86 ± 74.34 μm. In conclusion, the commercial membrane presented good performance for fluoride removal. In addition, the feasibility of producing sodium fluoride crystals using a membrane contactor has been confirmed.

Keywords: fluoride removal and recovery; reverse osmosis; osmotic membrane crystallization