

Economic Analysis of Hybrid Seawater Desalination Process Combining Forward Osmosis, Crystallization, and Reverse Osmosis with Experiments of Spiral Wound Membrane Modules

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Membrane based seawater desalination technologies are promising solutions to meet a growing water demand. Reverse osmosis (RO) is one of the most well-known and effective technologies for seawater desalination. At present, a lot of studies to reduce energy costs for seawater desalination have been studied compared to RO. In this study, the hybrid desalination processes, FO, crystallization, RO are proposed. Forward osmosis (FO) is a concentration-driven membrane process that water molecules migrate by diffusion into a more concentrated solution through a semi-permeable membrane. Since FO does not require much energy input compared to reverse osmosis (RO), it is worth attempting to combine together with crystallization. Sodium sulfate( $\text{Na}_2\text{SO}_4$ ), Potassium chlorate( $\text{KClO}_3$ ), Disodium phosphate( $\text{Na}_2\text{HPO}_4$ ) were used as draw solutions. Spiral wound module membrane modules for FO, and RO and refrigerators for crystallization were setup for experimental investigations. As a result, the energy consumptions and overall costs of the hybrid process using the selected draw solutes are lower than the typical RO process.