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Osmotically and thermally driven membrane processes for enhancement of water recovery in desalination processes

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ABSTRACT

Osmotically-driven membrane processes, including forward osmosis (FO) and pressure retarded osmosis (PRO), are emerging technologies that have come under renewed interest and subjected to numerous investigations in recent years. In FO, water is extracted from a feed solution utilizing the high osmotic pressure of a concentrated draw solution (DS) that flows on the opposite side of an FO membrane; RO or a distillation process can be utilized to reconcentrate the DS for reuse in the FO process and to produce purified water. The main advantages of FO include operation at very low hydraulic pressures, high rejection of a broad range of contaminants, and lower membrane fouling propensity than in pressure-driven membrane processes. Existing and potential applications of the osmosis phenomenon extend from water treatment and food processing to power generation and novel methods for controlled drug release. While FO relies on osmotic pressure driving force to separate water from a feed streams, thermally driven membrane processes, such as membrane distillation (MD), rely on vapor pressure difference across a microporous hydrophobic membranes to facilitate separation of volatile solvent (water from salt solution) or volatile solutes from impaired feed streams. The vapor pressure gradient is usually achieved by maintaining temperature difference between a warm feed solution and a colder distillate that flow on the opposite side of the membrane. In thermally-driven membrane processes, desalination and production of highly-purified water can be achieved in one step compared to osmotically-driven membrane processes, at much lower temperatures compared to distillation processes, and at much lower pressures compared to pressure-driven membrane processes. It can be most effectively and beneficially used when low-grade heat is readily available. Furthermore, compared to other membrane processes, in MD the salinity of the feed stream minimally affects the driving force for mass transport through the membrane; salts, even at high concentrations, only slightly reduce the partial vapor pressure of such feed streams. Thus, MD can be beneficially used to enhance water recovery in many desalination processes. In this paper, a brief review of the principles of FO and MD is provided. Special aspects of mass transport as well as the membranes used in the processes are discussed, and relevant results from recent studies are presented. Strengths and limitations of the FO and MD processes in a broad spectrum of applications are reviewed and discussed.

Keywords: Forward osmosis; Membrane distillation; Desalination; Pretreatment; Water recovery