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Membrane Permeability Threshold for Osmotic Power Plant Efficiency

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ABSTRACT

In a context of ever-growing electricity consumption and need for less polluting sources of energy, salinity gradient power (SGP) based on osmosis is a promising technology. Salinity difference between two solutions separated by a semi-permeable membrane leads to the pressure increase. The aim of this study is to find the critical permeability threshold of a membrane for the dimensioning an osmotic power plant. Using Spiegler-Kedem equations, the various fluxes across the membrane have been calculated, and delivered power is explicitly derived in terms of system parameters. A necessary condition for economic viability is that its upper bound is larger than a critical threshold value below which osmotic power plant is not profitable. As it is directly proportional to membrane permeability, fixing the optimal membrane permeability value will in turn enable conceive more efficient membranes specifically made for osmotic energy production, as such membranes do not exist today.

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1. Introduction

The considerable and very fast growing energy consumption consecutive to the economic development of many countries is acutely raising the question of avoiding disastrous environmental consequences which could inevitably occur if only conventional fossil sources are used. To cope with such situation, a large effort has been oriented toward other sources such as less damaging renewable ones (Lewis, *et al.*, 2011; Kumar, *et al.*, 2011). Aside solar, wind, geothermal and hydraulic sources, they also include other less evident ones which may however represent interesting alternatives in specific situations.

Such is the osmotic power which is the process of converting the pressure differential between water with high salinity and water with lower or no salinity into hydraulic pressure (Loeb, 1975; Mishra, 2013; Kho, 2010; The European Commission, 2004; Helfer, *et al.*, 2013; Skilhagen, *et al.*, 2012; Skilhagen, and Aaberg, 2012). The harnessing of this energy for conversion into power can be accomplished by means of Pressure Retarded Osmosis (PRO) (Kim, and Elimelech, 2013; Helfer, *et al.*, 2014; Wang, *et al.*, 2012). This technique uses a semipermeable membrane to separate a less concentrated solution, or solvent, (for example, fresh water) from a more concentrated and pressurized solution (for example sea water), allowing the solvent to pass to the concentrated solution side (Post, 2009). The additional volume increases the pressure on this side, which can be depressurized by a hydro-turbine to produce power and electricity (Kleiterp, 2012) .As seventy percent of Earth surface is covered with water, 97 percent of which is saltwater, the process created by mixing seawater with freshwater generates a resulting osmotic power which could serve as

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