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Limitations of osmotic gradient resource and hydraulic pressure on the efficiency of dual stage PRO process

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ABSTRACT

A dual stage PRO process has been proposed for power generation from a salinity gradient across a semi-permeable membrane. Both closed-loop and open-loop dual stage PRO system were evaluated using 2 M NaCl and Dead Sea as draw solutions, whereas the feed solution was either fresh water or seawater. The impact of feed salinity gradient resource and feed pressure on the net power generation and water flux were evaluated. The results showed that power density in stage one reached a maximum amount at $\Delta P = \pi/2$, but the maximum net power generation occurred at $\Delta P = \pi/2$. This result was mainly attributed to the variation of net driving pressure in stage one and two of the PRO process. The dual stage PRO process was found to perform better at high osmotic pressure gradient across the PRO membrane, for example when Dead Sea brine or highly concentrated NaCl was the draw solution. Total power generation in the dual stage PRO process was up to 40% higher than that in the conventional PRO process. This outcome was achieved through harvesting the rest of the energy remaining in the diluted draw solution. Therefore, a dual stage PRO process has the potential of maximizing power generation from a salinity gradient resource.

Keywords: Dual stage; Pressure retarded osmosis; Renewable energy; High efficiency; Osmotic energy

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