Numerical simulation of electrokinetic desalination using parallel permselective microchannels

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Abstract

The shortage of drinking water makes the development of massive desalination technologies urgent. A novel high-throughput microfluidic desalination system is proposed, in which a cation-selective membrane with paralleled microchannels is deployed at the middle part of a macroscale channel (see Fig. 1(a)). Due to the permselectivity of membranes, cations can go through membranes and anions are blocked, leading to the formation of ion depletion zone. Accordingly, as the fluid flows, the fluid in the downstream is desalted, that is, salt removal functionalities is implemented [1] (see Fig.1 (b)). Here, numerical simulation using COMSOL is performed to investigate such feasibility of the methods and elaborate the mechanism based on previous researches [2]. Desalination performance in terms of salt rejection rate η and the average fluid velocity $\bar{u}$ is analyzed (see Fig. 1(c) and (d)). The cross membrane voltage $\left(V_{cm} = \left(V_L + V_R\right)/2 - V_m\right)$ and external pressure P_0 are shown to have positive effects on $\bar{u}$, while opposite effects on η. The desalination performance is almost unrelated with the number of parallel microchannels in the membranes n when n is more than 7 (see Fig. 1(e)). The energy efficiency is also discussed to demonstrate the validity of the system. It is estimated that the volumetric energy consumption is ~20kWh/m^3 (see Fig. 1(f)). The mechanism elaborated and novel parallel method proposed here may provide significant guidance to the design and optimization of large-scale electric field-driven seawater desalination system.

Keywords: Desalination; Ion concentration polarization; microchannel parallelization

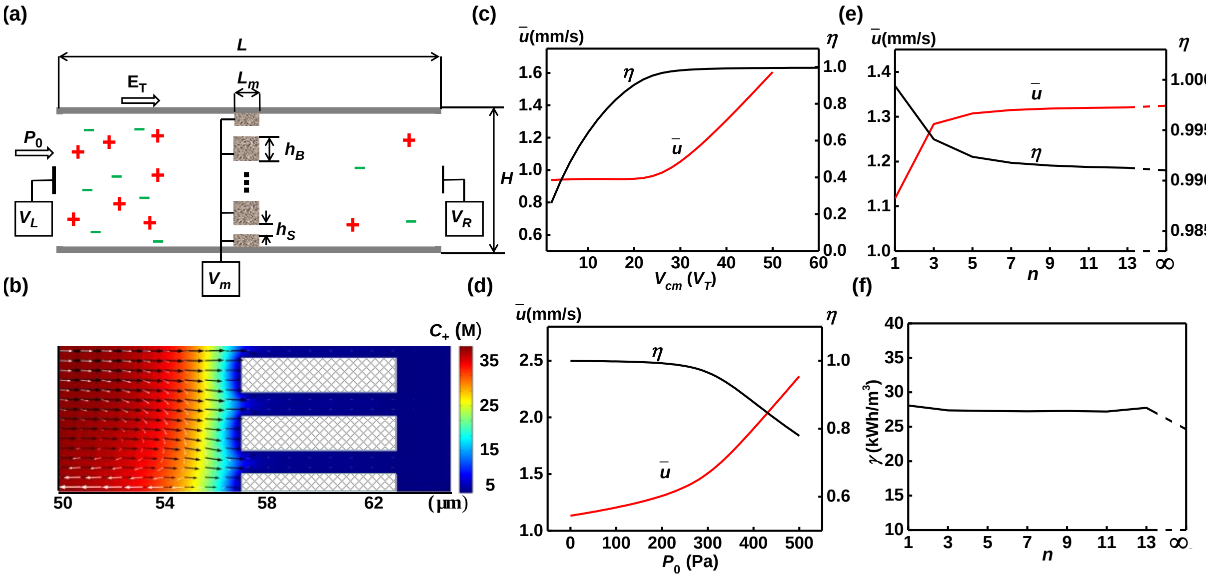

Fig. 1(a) Diagram of computational model; (b) distribution of Na^+ concentration; dependencies of η and $\bar{u}$ on (c) P_0, (d) V_{cm}, (e) n; and (f) dependency of volumetric energy consumption on n.

References

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