Numerical simulation of electroconvection based on electrodialysis: effects of shear flow on the system

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Abstract

Electrodialysis has been used as an important method of desalination for decades, yet current industrial systems are still running in low voltage regime. We investigate the feasibility of electrodialysis desalination in high voltage regime. We study electroconvection and ion concentration polarization near the ion exchange membranes of two-dimensional electrodialysis unit under shear flow through numerical simulation. Coupled Navier-Stokes, Nernst-Planck and Poisson equations are solved using the software Comsol Multiphysics 5.2a. Our results reproduce the typical current-voltage (*I-V*) curve (see Fig. 1(a)) including Ohmic, limiting current and overlimiting current regimes. The ion concentration distribution is consistent with that observed in experiments [1]. The electroconvective fluid flows generate vortices of different heights and ion depletion zone near two membrane surfaces due to the difference of mobility (see Fig. 1(b)). Mechanisms of this complicated electroconvection are elaborated and it is confirmed that vertical electroconvection is the key mechanism behind overlimiting current. Factors that influence the electroconvective instability such as inlet velocity, applied voltage and channel width are analyzed. Performances of such a system, in terms of desalting efficiency and volumetric energy consumption, can be greatly improved by changing the working conditions [2]. The results and findings of the theoretical study have significant impacts on the practical application of electrodialysis in high voltage ranges.

Keywords: Electrodialysis, shear flow, electroconvection, overlimiting current, desalination

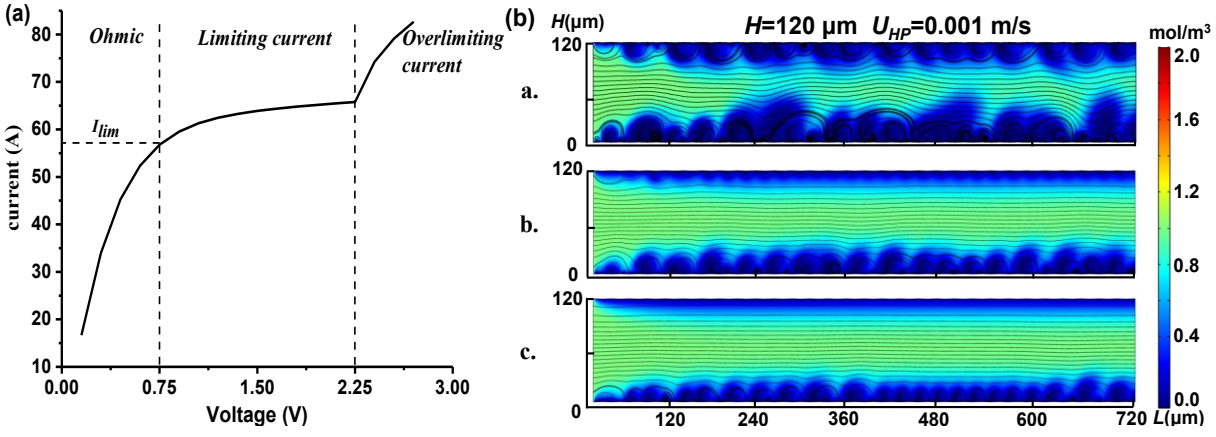

Figure 1. (a) *I-V* curve and (b) distribution of concentration (Na^+) and streamlines of fluid flow

References

[1] B. Kim, R. Kwak, H. J. Kwon, V. Pham, M. Kim, B. Anzi, G. Lim and J. Han. (2016) Purification of High Salinity Brine by Multi-Stage Ion Concentration Polarization Desalination, *Scientific Reports* **6**, 31850.

[2] R. Kwak, Guan, G. F., Peng, W. K., and J. Han. (2013) Microscale Electrodialysis: Concentration Profiling and Vortex Visualization, *Desalination* **308**, 138–146.