By Using Current–Voltage Relation and Electrochemical Impedance Spectroscopy to Study the Transport Characteristics of Copper Cations through a Cationic Exchange Membrane under Electroconvection Operation

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Abstract

The electrodialysis (ED) system to separate the cations from industrial wastewater has been considered as a promising technique. Different electric fields applied on the ED process will induce three distinct operation phenomena including ohmic, limiting current, and electroconvection region, respectively. The fundamental of cations transport under ohmic and limiting current already have been derived to clear theories, however, that of cations transport under the electroconvection is still obscure. This study adopted the current–voltage relation (I–V curve) and the electrochemical impedance spectroscopy (EIS) to study the transport characteristics of copper cations through a cationic exchange membrane (CMX) under electroconvection operation. In addition, the treated solution of CuSO₄ with and without dissolved oxygen (DO) was employed to observe the DO impacts.

Results indicate that the transport number of copper cations in the electroconvection region (according to I–V tests) is quite identical (namely 1.0). This illustrates the proportionality of the electrical voltage and current not only suits to ohmic region but also to the electroconvection region. From the EIS diagrams, the magnitude order of the capacitance associated with the double layer (C_{dl}) is limiting current > ohmic > electroconvection. This implies the electroconvection may disturb the interface of the membrane and result in the reducing thickness of the double layer. According to the Nyquist plots, the impedance of the membrane (C_m and R_m) in ohmic region is greater than that in electroconvection region, which is consistent with the above explanation. Results present that the solution without DO is favor to the copper transport to some extent under the electroconvection operation.

Keywords: Cationic Exchange Membrane, Electrodialysis, Electroconvection, Electrochemical Impedance Spectroscopy, Transport Number.

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