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研究论文

纳滤膜对电解质溶液分离特性的理论研究**(I):** 单一电解质溶液

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摘要 电解质溶液在纳滤膜中的截留率对于膜法海水淡化和重金属离子的脱除非常重要.
本文假定膜具有狭缝状孔, 采用扩展Nernst-Planck方程、Donnan平衡模型和Gouy-Chapman理论来描述电解质溶液中离子在膜孔内的传递现象. 使用纯水透过系数、
膜孔径及膜表面电势来表征纳滤膜的分离特征, 这三个参数可通过Levenberg-Marquardt方法由实验数据关联得到.
本文使用该模型计算了两种商用纳滤膜(NF45和SU200)对1-1型(NaCl, KCl, LiCl), 2-1型(K_2SO_4)和2-2型($MgSO_4$)
单一电解质溶液的截留率, 并与实验数据进行了比较, 两者吻合较好.
计算结果表明电解质溶液中离子在纳滤膜孔内传递的主要机理是离子的扩散和电迁移,
纳滤膜对电解质溶液中离子的分离效果主要由空间位阻和静电效应决定.
该模型在低浓度时对电解质溶液通过纳滤膜的截留率计算结果较准确, 但对高浓度电解质溶液则偏差较大.
关键词 膜分离 纳滤膜 电解质水溶液 扩展Nernst-Planck方程 Gouy-Chapman理论
分类号

Theoretical Investigation on the Separation Characteristics of Elec-trolyte Solutions with the Nanofiltration Membranes (I): Single Elec-trolyte Solutions

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Abstract The rejections of electrolyte solution in the nanofiltration membranes are very important for the desalination of sea water and the removal of heavy metal ions from water. In this work the nanofiltration membrane pores were modeled as slit-like pores with fixed pore size and surface electrical potential. The extended Nernst-Planck equation was used for the calculation of the ion fluxes through the membrane pores, in which the local concentrations of electrolyte ions on the membrane surfaces were evaluated from the Donnan equi-librium model and the charge densities on the membrane surfaces were predicted from the Gouy-Chapman theory. The parameters characterizing the nanofiltration membranes are the pure water permeability, pore width and membrane surface electrical potential, which are regressed from the experimental ion fluxes and rejections of single-electrolyte solutions in the nanofiltration membranes using Levenberg-Marquardt non-linear parameter estimation method. The rejections of 1∶ 1 (NaCl, KCl, LiCl), 2∶ 1 (K_2SO_4) and 2∶ 2 ($MgSO_4$) in the two commerical nanofiltration membranes (NF45 and SU200) are calculated using the developed model and compared with the ex-perimental data. Good agreements between theoretical and experimental results are achieved. The calculated results show that diffusion and electro-migration are the main mechanisms of ion transport. The steric and electrostatic effects are dominant for the ion rejections in nanofiltraiton (NF) membranes. Comparisons of the calculated ion rejections with the experimental data indicate that the model gave satisfactory results at low concentration for single-electrolyte solutions, while deviations are found at high concentration.

Key words membrane separation nanofiltration electrolyte solution extended Nernst-Planck equation Gouy-Chapman theory

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