研究论文

毛细管电泳样品电堆积富集过程的数值研究

曹军,洪芳军,郑平

上海交通大学机械与动力工程学院, 上海　200240

摘要　　毛细管电泳样品电堆积富集过程可以浓缩样品组分,从而提高检测灵敏度,是一种有效的样品富集技术。本文通过合理的简化和假设,把毛细管中电堆积富集过程中所涉及的主要变量根据电势分布方程、缓冲溶液的浓度方程和样品粒子的质量传输方程进行耦合求解,建立了一个一维的数学模型,并应用有限元的方法对该模型进行了求解。计算结果给出了毛细管中缓冲溶液浓度及电场强度的分布随时间变化的过程,以及富集过程中毛细管中的电势分布曲线;得到了样品粒子浓度在电堆积富集过程和富集之后的再次扩散过程中的分布曲线以及正、负样品粒子的分离过程;最后分析了不同缓冲溶液浓度比对样品富集效果的影响。该研究为样品电堆积富集技术的进一步完善提供了一种简单可行的理论研究方法。

关键词　　毛细管电泳　　样品富集　　缓冲溶液　　数值研究

分类号

Numerical Study on Sample Stacking in Capillary Electrophoresis

CAO Jun, HONG Fangjun, CHENG Ping

School of Mechanical &Power Engineering, Shanghai Jiao Tong University, Shanghai 200240, China

Abstract

  Sample stacking in capillary electrophoresis is one of the effective techniques to concentrate sample species, thus improving the detection sensitivity. A 1-D mathematical model, including the electrical potential distribution equation, the buffer concentration equation, as well as the sample electromigration and diffusion equation, is developed through proper simplifications and assumptions to study the sample stacking process in capillary electrophoresis. These coupled governing equations are solved using finite element method (FEM). The variations of the buffer concentration and the electrical field strength distribution with time as well as the electrical potential distribution in capillary during sample stacking are obtained. The sample stacking and the sample diffusion after stacking as well as the separation process of sample cations and anions are presented. It is found that the best stacking effect occurs near the entrance where the species have not been separated well. With the development of time, the stacking effect deteriorates while the distance between the positively and negatively charged particles becomes larger, and the separation effect becomes better. The effect of buffer concentration ratio on sample stacking is also analyzed. It is found that the relationship between sample stacking effect and the buffer concentration ratio is not linear and the maximum stacking effect is achieved within less time and migration distance when the buffer concentration ratio is higher because of the stronger electrical field strength in sample plug region. It is anticipated that the numerical model developed in this paper is helpful for the design and optimization of sample stacking devices.

Key words　capillary electrophoresis （CE）　sample stacking　buffer　numerical study

通讯作者　郑平 pingcheng@sjtu.edu.cn