Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences

A Sandwich-Injection Method for Microchip Electrophoresis

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Abstract

Here, we present a sandwich-injection method for controlling discrete sample injection in μ-CE. This method involves four accessory arm channels in which symmetrical potentials are loaded to form a unique parallel electric field distribution to confine the spreading of sample plugs and prevent sample leakage. The virtues of the novel injection technique were demonstrated with numerical models and experiments.

Introduction

In μ-CE, the injection system is one of the key elements in the sample-handling process since the performance of μ-CE techniques depends strongly on the shape and size of the sample plug introduced into the separation channel. Several different injection configurations have been developed for the delivery of discrete samples, including the T-form, the cross-form, the double-T form, double-cross form and the pinched-cross form. However, these injection methods have some limitations, such as the diffusion and dispersion of sample at the cross location, the distort shape plugs delivered, and the leakage effect in separation phase, which tend to reduce the detection performance of the device. To circumvent these limitations, we develop a sandwich-form injection system that employs a unique parallel electric field distribution in the intersection of sample channel and separation channel to confine the diffusion of analyte in injection phase and prevent the sample leakage in separation phase.

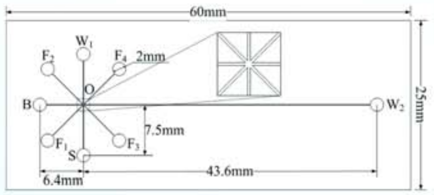

Fig. 1 Schematic of the sandwich-injection device

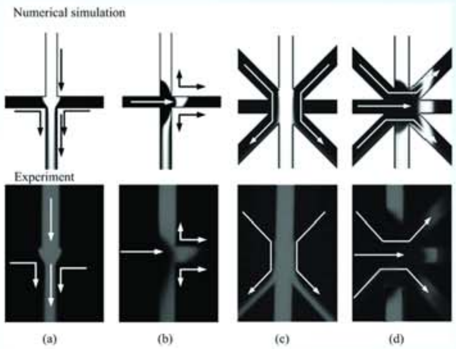

Fig. 2 Comparison of the shape of sample plugs delivered by (a) cross-form injection method and (b)sandwich-form injection method

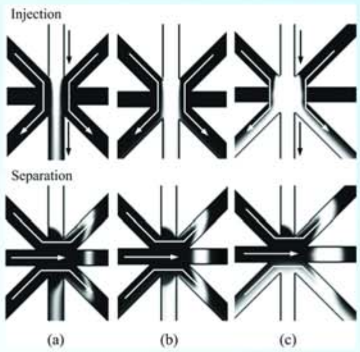

Fig. 3 Comparison of the volume of sample plugs generated by different focusing voltages

Experiments

Details of geometry and reservoir labeling scheme of the sandwich injection system are shown in Fig. 1. The basic operating principle of the sandwich injection device may be described as follows: Firstly sample is drawn from the sample reservoir (S) across the injection intersection toward the sample waste reservoir (W1) by an electric field along the sample channel. Meanwhile appropriate electrical fields are loaded in the focusing channels (i.e., OF1, OF2, OF3, OF4) to form a parallel electric field distribution along the sample channel at the intersection of sample channel and separation channel, which counteracts the diffusion of sample and keep the shape of sample band (as shown in Fig. 2c). Then the sandwich injection device changes the direction of electric fields to switch the phase from injection to the separation. Through the application of appropriate electrical fields to separation channel and each of focusing channels, a parallel electric field along the separation channel at the junction of sample channel and separation channel is formed to prevent sample leakage during separation phase (as shown in Fig. 2d).

Results and Discussion

Here we compare the sandwich-form injection method with the conventional cross-form injection method. Both experimental and numerical simulation results here prove that the sandwich injection technique is a more efficient injection method, which can provide a high-quality sample plug with well-defined shape for high-performance detection purposes in μ-CE (as shown in Fig. 2). Furthermore, the sandwich-form injection system can also deliver the variable-volume sample plugs into the separation channel by applying the different focusing voltages in the loading step(as shown in Fig. 3). Through appropriate use of the electric focusing ratio (Focusing electric field/Central electric field), the proposed system is not only capable of performing the same function as the conventional cross injection system, but is also able to generation different volumes of sample plug.

Conclusions

In this paper, we propose a novel sandwich injection technique for microchip electrophoresis. This new technique can produce a high-quality sample plug with variable volumes and well-defined shape for high-performance detection purposes. Both numerical simulation and experimental results demonstrate the effectiveness of the sandwich injection technique in enhancing the quality of sample plugs for μ-CE.

Acknowledgements

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