On-Chip Sample Pretreatment for Biochips : Nanoporous Polymer Membranes and Dielectrophoresis

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The advent of microfluidic chips (or biochip) enables automation of a labor-intensive biochemical analysis process and reduction of sample consumption. Numerous studies have been performed to incorporate various functions such as sample cleanup, sample preconcentration, mixing, reaction, separation, and detection into the biochips over the past decade. However, most studies were focused on miniaturization of sampling and sample analysis. Now, more research has paid attention to miniaturizing the sample pretreatment process because it is a bottle neck of full automation of the entire process. This presentation will discuss on-chip sample pretreatment techniques developed using nanoporous polymer membranes and numerical studies on dielectrophoresis in microchannels.

A unique technique was developed to laser-pattern nanoporous polymer membranes in a biochipusing a projection lithography and phase separation polymerization. The membranes areused for microdialysis and preconcentration of proteins, controlling the membrane size, shape and the pore size. For microdialysis, mass exchangers are fabricated in fused silica chip. About 35 mm thick membranes are polymerized in the exchangers along the microchannel centerline of the exchanger. Results indicate that the mass exchanger can be used for desalting protein solutions or separating cytosolic proteins from cell membrane fragments according to the membrane pore size. On the other hand, a 50 mm thick membrane is fabricated at the junction of a simple cross channel for electrophoretic sample preconcentration. Results show that the protein concentration increases at least by two orders of magnitude and that the increase is linearly proportion to concentration time and electric field strength applied.

Numerical studies using an in-house code havebeen performed to characterize electrokinetic and dielectrophoretic phenomena in microchannels. The two phenomena are frequently used for on-chip sample pretreatment. Understanding transport physics of bio-samples due to the electrokinesis and dielectrophoresis is critical for designing biochips with optimal dimensions and layout of microchannel network and for controlling fluid and sample particles during the operation. Numerical studies provide good insights to the transport physics and enable optimization of design parameters reducing trial-and-errors in biochip developments.