Microchip Devices for Chemical Separations: How far can we go?

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The first condensed phase chemical separations were performed on a microfabricated device (microchip) nearly a decade ago. Although first viewed as a curiosity, microchip separations have gained increasing interest over the past few years. Some attributes of this technology are the ability to perform moderately efficient separations 10 to 100 times faster than conventional technology while utilizing sample volumes that are 100 - 10,000 times smaller. In addition, microchips promise to monolithically incorporate sample processing procedures, which allows automation of chemical and biochemical assays. More recently we have been attempting to demonstrate that high efficiency separations can also be performed on small footprint microchip devices. The efficiency of electrokinetically driven separations is proportional to the voltage drop between the points of injection and detection under diffusion limited conditions. Diffusion limited conditions can be maintained under small separation distances due to the ability to achieve very short (≈ 10 μm) injection plugs. Nonetheless, channel lengths greater than 5 cm are needed for high efficiency separations so that electric field strengths can be maintained at an acceptable level. Long separation distances and small footprint devices require that the separation channel be folded to fit into a small area. The folding process introduces yet another plate height term, i.e., geometrical band broadening associated with racetrack effects at channel curves. We have used a one-dimensional model of geometrical band broadening, developed in our laboratory, to design a channel architecture that minimizes this plate height term. The result is a spiral design that has allowed the generation of more than one million plates in less than a minute. We have also monolithically integrated two-dimensional separations onto microchip devices as another means to increase peak capacity. These two experimental strategies for increasing separative performance will be discussed.

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