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Micro / Nanofluidic Systems for Molecular Processing : Fractionation, Concentration, and Detection

Recent advances in fabrication techniques allow one to create regular nanofluidic pores and channels down to ~10 nm in critical dimension, with excellent uniformity and size control. This creates unique opportunities for advancing both nanoscience and nanotechnology. Study of nanoscale molecular interaction with surrounding nanostructure has many applications in separation science, membrane engineering, and drug delivery. Nanofluidic channels can provide very uniform, well controlled experimental platform for studying these phenomena. In addition, detailed study of nanoscale transport of ions and molecules through confined environment would lead to ideas for novel nanofluidic devices. In this talk, I will demonstrate some of the examples of nanofluidic devices, which can have impacts both in the science and technology.

One of the important advantages of MEMS-fabricated nanofilter membranes is the flexibility of membrane system design, which is not readily achievable in random nanoporous materials. As an example, a novel biomolecule (protein and DNA) separation device is presented in the talk. We have successfully designed and fabricated an anisotropic sieving structure that can be used for size separation of various biomolecules(Fu, Yoo and Han 2006). The sieving structure consists of a two-dimensional periodic array of nanofluidic filter (nanofilter). The bidirectional electrophoretic motion of biomolecules in the sieving structure causes molecules of different sizes to follow radically different paths, leading to efficient separation. Using this sieving structure, we have implemented a high-throughput, continuous-flow biomolecule separation device and evaluated its performance on various biologically relevant molecules(Fu, Schoch, Stevens, Tannenbaum and Han 2006). Our device can continuously size-fractionate a wide range of dsDNA fragments (50bp–23kbp) and protein complexes (11kDa–200kDa) in less than 1 min. It has to be recognized that the *anisotropic* sieving properties designed into the system is the key to the operation, and such an operation would not be readily possible with random, isotropic sieving matrix. In addition, this nanofluidic molecular filter array is an ideal experimental platform to study Ogston- and other molecular sieving behavior, with well-defined pore size and shape.

We also demonstrated nanofluidic biomolecule preconcentrator(Wang, Stevens and Han 2005), where dilute protein samples can be efficiently concentrated for more efficient downstream detection. In addition to its potential as a signal enhancement strategy for proteomics, the device is a model system for studying nonlinear electrokinetic phenomena and concentration polarization(Kim, Wang, Lee, Jang and Han 2007), which has relevance in many perm-selective membrane applications such as Nafion®.

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