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Nanofluidic Size-Exclusion Chromatograph

This device would perform the functions of a much larger instrument.

NASA's Jet Propulsion Laboratory, Pasadena, California

Efforts are under way to develop a nanofluidic size-exclusion chromatograph (SEC), which would be a compact, robust, lightweight instrument for separating molecules of interest according to their sizes and measuring their relative abundances in small samples. About as large as a deck of playing cards, the nanofluidic SEC would serve, in effect, as a "laboratory on a chip" that would perform the functions of a much larger, conventional, bench-top SEC and ancillary equipment, while consuming much less power and much smaller quantities of reagent and sample materials. Its compactness and low power demand would render it attractive for field applications in which, typically, it would be used to identify and quantitate a broad range of polar and nonpolar organic compounds in soil, ice, and water samples.

Size-exclusion chromatography is a special case of high-performance liquid chromatography. In a conventional SEC, a sample plug is driven by pressure along a column packed with silica or polymer beads that contain uniform nanopores. The interstices between, and the pores in, the beads collectively constitute a size-exclusion network. Molecules follow different paths through the size-exclusion network, such that characteristic elution times can be related to sizes of molecules: basically, smaller molecules reach the downstream end of the column after the larger ones do because the smaller ones enter minor pores and stay there for a while, whereas the larger ones do not enter the pores. The volume accessible to molecules gradually diminishes as their size increases. All molecules bigger than a pore size elute together. For most substances, the elution times and sizes of molecules can be correlated directly with molecular weights. Hence, by measuring the flux of molecules arriving at the downstream end as a function of time, one can obtain a liquid mass spectrum for the molecules present in a sample over a broad range of molecular weights.

The developmental nanofluidic SEC is based on the same size-separation principle as that of a conventional SEC. However, instead of a packed macroscopic column containing porous beads, the nanofluidic SEC would contain a size-exclusion network in a miniature column in the form of a microscopic channel containing nanometer-scale features (see figure). More specifically, the nanometer-scale features in the channel would be sized, shaped, and positioned to define a matrix of micron-width subchannels topped with a gap of varying thickness of the order of tens of nanometers. The miniature column would be fabricated by established techniques now used to produce integrated circuits (ICs) and microelectromechanical systems (MEMS). One or more device(s) to detect molecules could be integrated onto the column chip at the downstream end. These devices could be based, for example, on electrochemical (in particular, amperometric) and laser-induced-fluorescence detection techniques.

This work was done by Sabrina Feldman, Danielle Svehla, Frank Grunthaner, Jason Feldman, and P. Shakkottai of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

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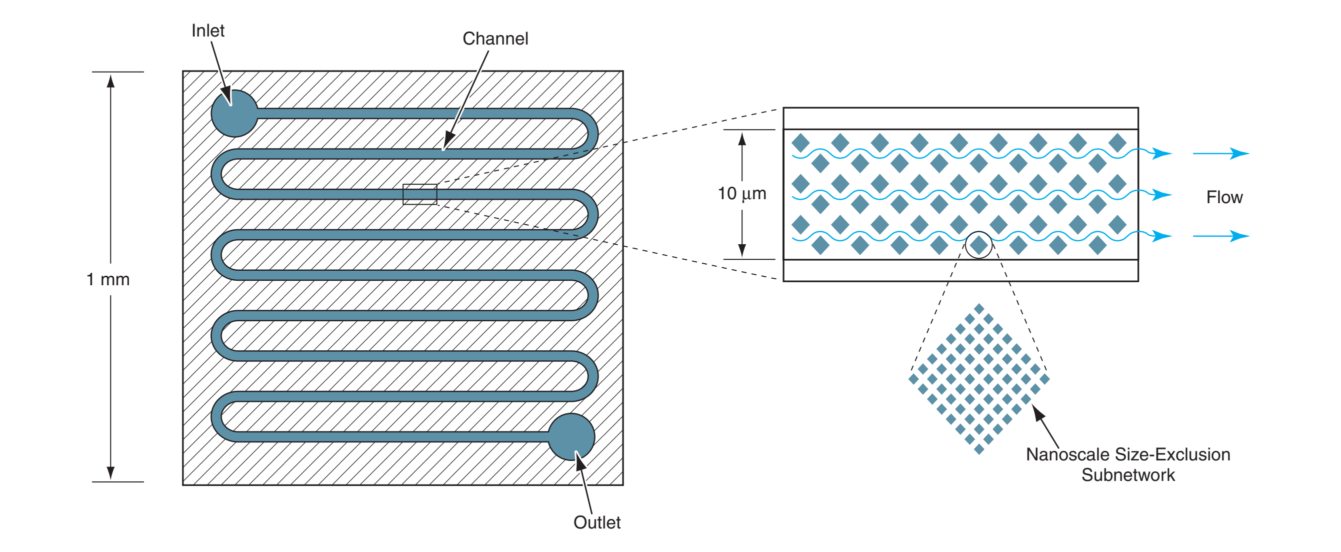

A **Size-Separation Network in a Miniature Channel** on a chip would contain nanoscale features. The channel and features would be formed as one piece in a chip by use of IC and MEMS fabrication techniques.