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Editorial

Microfluidics: An Overview

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EDITORIAL

Microfluidics is the study of the behaviour, precise control, and manipulation of fluids that are geometrically restricted to a small scale (usually sub-millimeter), where surface forces overpower volumetric forces. Engineering, physics, chemistry, biochemistry, nanotechnology, and biotechnology are all part of this multidisciplinary field. Microfluidics has been used in the production of inkjet printheads, DNA chips, lab-on-a-chip technology, micro-propulsion, and micro-thermal technologies since the early 1980s. Micro typically refers to one of the following characteristics:

- Small volumes (µL, nL, pL, fL)
- Low energy consumption
- Microdomain effects
- Small size

Microfluidic systems usually transport, combine, detach, or process fluids. Capillary flow modifying components, such as flow resistors and flow accelerators, are used in a variety of applications to regulate fluid flow passively using capillary forces. External actuation means are often used in some applications for media transport that is guided. Rotary drives that use centrifugal forces to transport fluid on passive chips are an example. Active microfluidics is the controlled manipulation of a working fluid by active (micro) components like micropumps and microvalves. Micropumps are used to continuously supply fluids or to dosing. The flow path or mode of movement of pumped liquids is determined by microvalves. Processes that would usually be carried out in a lab are often miniaturised on a single chip, improving performance and mobility while reducing sample and reagent volumes.

The microfluidic behaviour of fluids differs from "macrofluidic" behaviour in that surface tension, energy dissipation, and fluidic resistance begin to control the system. Microfluidics investigates how these behaviours alter and how they can be manipulated for new applications. Some interesting and often counterintuitive properties emerge at small scales (channel sizes ranging from 100 nanometers to 500 micrometres). The Reynolds number (which compares the effect of a fluid's momentum to the effect of viscosity) can become extremely tiny. Since the flow becomes laminar rather than turbulent, co-flowing fluids do not usually mix in the conventional sense; molecular transport between them must also be accomplished by diffusion. In single and multi-step reactions, high specificity of chemical and physical properties (concentration, pH, temperature, shear force, etc.) can also be ensured, resulting in more uniform reaction conditions and higher grade products. The only constraint on microfluidic flows is geometrical length scale; the modalities and methods used to achieve this geometrical constraint are highly dependent on the targeted application. Microfluidic flows have traditionally been produced within closed channels with a cross section of 10 m x 10 m. Each of these methods has its own set of techniques for maintaining stable fluid flow that have been refined over time. Fluid activity and control in open microchannels were first demonstrated in 2005 and used in air-to-liquid sample processing and chromatography. At least one boundary of the device is eliminated in open microfluidics, exposing the fluid to air or another interface. Access to the moving liquid for intervention, a greater liquid-gas surface area, and reduced bubble formation are all advantages of open microfluidics.

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