# Microfluidic Reactor for Polymer Synthesis

► Polymer Synthesis within Microfluidic Reactor

# Microfluidic Rotary Pump

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## Synonyms

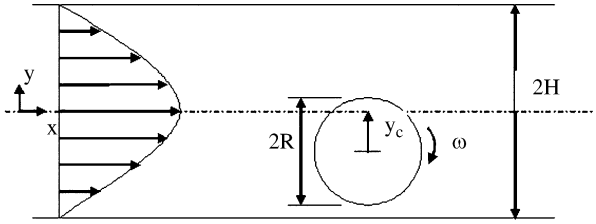
Viscous pump; Micro/Nanofluidics

## Definition

Conventional mechanical pumps based on centrifugal or axial turbomachinery are not suitable for micro and nano scales where the Reynolds numbers are usually small. Centrifugal and inertial forces are negligible, and viscous forces dominate the flow field in this length scale (an excellent review can be found on the physics of fluid flow at microscale in [1]). A microfluidic rotary pump, which is proposed by Sen et al. [2], is a device that is used for pumping fluids in microfluidic applications at extremely low Reynolds number. This miniature device consists of a rotating cylinder placed eccentrically inside a microchannel where the axis of the cylinder is perpendicular to the flow direction (see Fig. 1). Since it is placed asymmetrically, there exists a viscous resistance difference between the small and large gaps between the cylinder and the walls (i. e. unequally distributed shear force on the upper and lower surface of the rotating cylinder), which causes a net flow along the channel. They are capable of pumping very small flow rates which is desired for many medical and biological applications such as drug delivery.

## Overview

The operation of the rotary pump depends on the viscous forces and can operate in any situation where viscous forces are dominant. Therefore, they are suitable for flow of low viscosity liquids in micro ducts as well as the flow of highly viscous liquids such as heavy polymers in macro ducts. Together with its simplicity from design point of view and this viscous nature makes rotary pumps suitable for scientific and industrial applications of MEMS (Micro-Electro-Mechanical-Systems), NEMS (Nano-Electro-Mechanical-Systems) and LOC (Lab-on-Chip) technologies.




**Microfluidic Rotary Pump, Figure 1** Schematic drawing of microfluidic rotary pump. Eccentricity, $\varepsilon = y_c/(H-R)$. $\varepsilon = 0$ means the cylinder is at the center, $\varepsilon = 1$ means the cylinder touches the bottom wall

The channel height, eccentricity (i. e. degree of asymmetry, $\varepsilon = y_c/(H-R)$, see Fig. 1), Reynolds number, channel cross-section and the angular velocity of the rotating cylinder have the effect on the performance of the pump. These effects are extensively studied by many researches [2–8]. Sen et al. [2] first proposed the use of microfluidic rotary pump and conducted some experiments for circular, square and rectangular cross-section rotating rotors. 2D, steady [3] and transient [4, 5], and 3D, steady [6] numerical analysis of the rotary pump is studied for circular as well as the square and rectangular [5] cross-sectional rotors. Thermal effects due to viscous dissipation on pump performance are also analyzed by considering the temperature dependent fluid properties [7]. Closed form, analytical expressions are derived for the flow rate and pressure drop along the channel are derived by using lubrication approximation [8]. The effect of slip-flow boundary condition is also investigated [3]. Another challenging application of this eccentric cylinder inside a microchannel is proposed by DeCourtye et al. [6] as a microturbine which can be used as a microsensor for measuring exceedingly small flow rates in micro/nanofluidic applications.

## Cross References

► Centrifugal Microfludics
► Electrical Pumps
► Magnetic Pumps
► Thermocapillary Pumping

## References

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## Microfluidics

► Control of Micro-Fluidics
► Lattice Poisson–Boltzmann Method, Analysis of Electroosmotic Microfluidics
► Microfluidics for Studies of Apoptosis

## Microfluidic Sample Manipulation

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### Synonyms

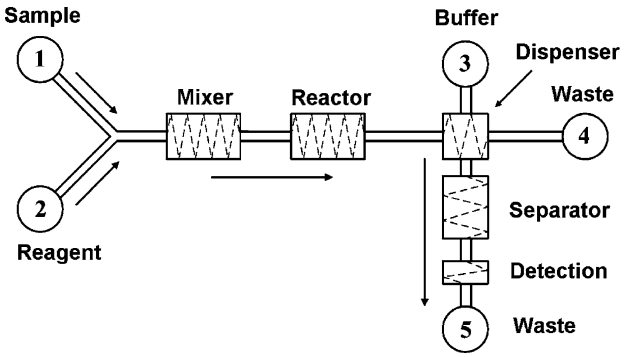
Sample handling; Sample preparation; Sample transport

### Definition

The term *microfluidic sample manipulation* refers to the processes involved in controlling the movement of small volumes of fluid or particles around a network of interconnected microchannels. These processes include sample introduction, injection, mixing, reaction, dispensing, separation, and detection, and are typically performed in a fully integrated micro total analysis system or a Lab-on-a-Chip device.

### Overview

Recent advances in the field of microelectronics have made possible the miniaturization of microfluidic systems on a microchip to carry out analytical analytes. Such microfluidic systems are generally known as a Lab-on-a-Chip or a micro total analysis system (μTAS). These systems perform a complete, integrated, and automated analysis of the target analyze in a complex sample matrix. In general, μTAS devices are designed to carry out the following functions: sample introduction, injection, mixing, reaction, dispensing, separation, and detection. Figure 1 presents a schematic illustration of a typical Lab-on-a-Chip. The sample of interest is introduced via port 1 and subsequently interacts with a reagent injected via port 2. The sample is then mixed with the reagent to facilitate the subsequent chemical reaction process. Finally, the reacted product is dispensed into a separation channel for component separation and detection using optical instrumentation.




**Microfluidic Sample Manipulation, Figure 1** Illustration of microfluidic components in typical Lab-on-a-Chip device

### Basic Methodology

#### Sample Introduction/Storage/Injection

To support the requirements of typical biochemistry applications, current micro-analytical systems are generally designed to manipulate aqueous liquid samples. The sample introduction process includes both sample preparation and sample storage in a suitable reservoir. Four major categories of sample preparation can be identified: separation of the sample from the sample matrix, sample preconcentration, sample derivatization, and sample pretreatment. The original sample generally contains large organic or inorganic particles, which must be removed using some form of cell membrane rupture technique. If the sample analyte is only available in trace amounts, the sample is generally preconcentrated prior to analysis by squeezing the available analyte molecules into a smaller volume to enhance the detection sensitivity. Sample derivatization involves the chemical transformation of the analyte to render it detectable by the particular detection system employed in the microchip. In the biochemical domain, the biomolecules of interest are commonly pretreated by labeling them specifically or nonspecifically with fluorescent labels. In the genomic research field, the DNA sample is often amplified using either polymerase chain reaction (PCR) or cleavage by restriction enzymes. Following the sample preparation process, the sample is introduced into