Microbeads as Functional Component in Microfluidic Systems

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There is currently interest in combining the functional components necessary for performing complex chemical and biochemical analyses into small, integrated units. In the present works, microbeads were used as functional component in microfluidic systems and applied to effective approach for mixing confluent streams and microanalytical methods detecting DNA targets.

A strategy for efficiently mixing solutions and carrying out multistep catalytic reactions in microfluidic systems involves immobilizing catalysts on microbeads, placing the beads into well-defined microreactor zones, and then passing reactants through one or more of the reactor zones to yield products. The catalyst-modified beads effectively mix reactants and increase the effective surface area of the channel interior, both of which improve reaction velocities compared to open channels. This approach is demonstrated using two sequential reactions catalyzed by glucose oxidase and horseradish peroxidase. In addition to providing a general route to chemical synthesis within microfluidic systems, this design strategy may also be applicable to modeling reaction pathways within cells and for bio/chemical sensing applications.

In DNA hybridization for detecting DNA targets, a UV-polymerizable PEG-based hydrogel was used to pattern microchambers within fluidic devices. Microbeads hosting different single-stranded DNA (ssDNA) probes on their surfaces were subsequently loaded into these microchambers and then used for the detection and the screening of specific DNA oligonucleotides in DNA mixtures. The key components of these devices are photopolymerized hydrogels, which act as passive switches that are activated by modulating the mode of mass transport: no special solution conditions (such as pH change) are required. The versatility of this design strategy is demonstrated by selective bead-based capture and release of DNA oligos. Specifically, a solution containing one or more synthetic oligonucleotides was flowed through a linear array of bead-containing microchambers. If the complement DNA (cDNA) for one of the targets is present on a bead it is extracted from the mixture. The cDNA could subsequently be recovered from the microchamber.