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Optimization of magnetic actuation protocol to enhance mass transfer in solid/liquid microfluidic systems

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Apart from homogenization, suspension or dispersion, enhancement of mass transfer in a solid/liquid system is one of the most frequent stirrer tasks in process technology. Mass transfer resistance at the boundary layer around a particle plays a crucial role among others in heterogeneous catalysis as well as in sorption from strongly diluted solutions, as it may often limit the total reaction rate. It is therefore of particular interest to accelerate mass transfer in such systems. The use of micrometric magnetic particles (MMPs) offers the advantage of a large specific surface for chemical binding, in combination with a high mobility imposed by the long range magnetic forces acting on them. The movement of MMPs can be controlled by the intensity and orientation of an external magnetic field. Functionalized MMPs can also act as a support for homogeneous and heterogeneous catalysts and their magnetic actuation enhances mass transfer in laminar flow. To achieve the maximum enhancement in mass transfer rate, one should increase particle superficial velocity (Reynolds number) and at the same time provide an alternating external force on the boundary layer by acceleration/deceleration of the MMPs. The reactor geometry is another important parameter which can significantly enhance the mass transfer rate.

In this lecture, recent advances in the synthesis, handling and manipulation of magnetic microparticles in microfluidic systems will be highlighted. Starting from the properties of magnetic microparticles and their synthesis in microfluidic chips, the hydrodynamics of particle motion and enhancement of mass transfer rate under magnetic actuation will be discussed. Finally, a novel magnetically stirred reactor concept will be presented.