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Quantification of the Mass Transfer at Fluid Interfaces in Microfluidic Channels

Carina Wismeth (1), Michael Manhart (2), Reinhard Niessner (1), and Thomas Baumann (1)

(1) Institute of Hydrochemistry, Technische Universität München, Munich, Germany, (2) Chair of Hydromechanics, Technische Universität München, Munich, Germany

Mass transfer rates at interfaces in a complex porous media are relevant in many environmental applications and control the functions of natural filter systems in subsurface environments. The mass transfer at fluid interfaces is associated with interface convection caused by local inhomogeneities in interface tension and hydrodynamic instabilities at the interface. If there is a surface tension gradient along the surface a shear stress jump is generated that results in fluid motion along the surface that is called Marangoni effect. These spontaneous convection currents can lead to an increased mass transfer of the transition component at the phase boundary and to an increased mixing of the phases. Therefore compensatory currents at the interface can have a significant influence on the subsurface transport of contaminants in the groundwater area, especially in the vadose zone.

Using microfluidic channels and advanced experimental techniques it is possible to measure the fluid flow and mass transfer rates directly and to quantify the effect of the Marangoni convection on the mass transfer at interfaces between a non-aqueous liquid and water with high temporal and spatial resolution. The use of fluorescent particles as well as the recording and analysis of their trajectories is intended to visualize interfacial processes and to quantify the mass transfer at fluid phase boundaries. Concentration gradients at the interface are analysed by spectroscopic methods and allow an assessment of the enrichment and depletion at the phase boundaries.

Extensive test series provide the experimental basis for quantifying and analysing the impact of the Marangoni effect on the mass transfer rates at interfaces in porous media in subsurface aquatic environments. Within this research project we concentrate on the effect of Marangoni convection on the mass transfer near an 1-octanol-water interface, which serves as a well defined proxy for non-aqueous phase liquids in porous media.

Experiments and a numerical simulation are closely coupled to provide a generic data set with high reproducibility and used to obtain highly resolved three-dimensional data of mass transfer in two- and three-phase systems to foster the understanding of subsurface transport, especially in the vadose zone.