

# Nanofluidics

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It is a pleasure to present this special issue on nanofluidics. Spurred by rapid technological advances in micromachining techniques, the research field of nanofluidics appeared about ten years ago. Nanofluidics is generally defined as the study of liquid flow in and around objects of 100 nm and less, and the applications thereof. Of course fluid research on this scale had already been studied for many decades, for example in colloid chemistry, the physics of fluids, and membrane science. However, the ability to manufacture devices with nanoscale precision is new and gave this area such a strong impetus that it came to be seen as a separate discipline.

For readers of “Analytical and Bioanalytical Chemistry” it is of great importance to become acquainted with nanofluidics, because most of its applications concern (bio)chemical separation. A number of specific contributions of nanofluidics to separation science can be pinpointed. To start on the fundamental level, phenomena involving nanometer length scales such as the Debye length and slip length can be investigated more rigorously. Applications then follow from the improvements in solvent and solute handling this brings. Second, nanofluidic studies have increased our understanding of the mechanisms behind classical separation methods. Control of dimensions and geometries down to the nanoscale enables the investigation of processes that hitherto were obscured by statistical variation of, e.g., surface properties. Third, with regard to applications, the nanoscale control of geometry has enabled the exploration of new separation mechanisms. Sieves

could be designed with pore shapes and pore charge distributions that were precisely tuned to exploit specific electrical, steric, or entropic molecular properties. Furthermore the ultrashort diffusion times on the nanoscale enabled separations based on molecular diffusion rates, e.g. in Brownian ratchets.

At present nanofluidic research is mostly explorative and researchers are still working towards real-life analytical applications. Important issues remain, especially concerning the ultrasmall quantities of analyte involved, which complicate detection and post-separation processes. Rapid advances have, however, been made in developing methods suitable for sensitive detection in nanospaces, for example optical (e.g. surface-enhanced Raman spectrometry) or electrical (e.g. nanowires and redox cycling).

In this special issue you will find a total of seven papers covering diverse nanofluidic topics. The review by Han Gardeniers focuses on the question of whether chemistry in nanoscale confinement differs from chemistry in free solution. Synthetic chemistry and protein folding are considered, in addition to analytical applications. A fundamental contribution is given by Frederik Detobel et al., who show that shear-driven chromatography in 120-nm deep nanochannels offers us the opportunity to study molecular adsorption by and desorption kinetics of the stationary phase. The contribution by Eric Kalman et al. concerns the properties of a gated membrane, belonging to a promising new class of membranes with tunable properties. The authors show that conical nanopores with a smallest opening of 6–12 nm can behave either as current-rectifiers or Ohmic resistors, depending on the gate potential applied. In the work reported in their paper Nicolas Durand et al. employed a 50-nm high nanochannel/nanoridge device designed to measure differences in analyte diffusivity. They show that the device can be

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used to detect rapid protein formation. The theoretical contribution of Zi Li et al. proposes a new type of device with asymmetric nanocavities, designed to separate rod-like nanoparticles such as short DNA. Interestingly, separation could be achieved by application of an AC voltage, in other words the device has rectifying properties. The paper of Yi-Heng Sen et al. reports on DNA translocation through 200 nm by 200 nm PDMS/glass nanochannels using amperometric detection. Translocation is found to occur only above a certain threshold voltage, which can probably be contributed to an entropic energy barrier. This research contributes to possible future nanopore DNA sensors. Finally, Edgar Goluch and co-authors employ electrochemical detection in a nanocavity. Using an interdigitated electrode array under an array of 75-nm high nanochannels, the authors achieve 100-fold current amplification by using redox cycling. They make an important step towards possible sensing applications by showing the immunity of the device for interfering redox-active substances if these are irreversibly

damaged in the process. I wish the reader much inspiration from these fascinating contributions to this young field.

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