Microrheology and Rheological Phenomena in Microfluidics
2006 Workshop of the German Rheological Society (DRG)

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The 2006 workshop of the German Rheological Society in Karlsruhe combined two very recent and new aspects of rheology: microrheology and microfluidics. In both areas a still increasing number of scientific publications and technical innovations can be noted. Naturally connected, not only by the similar name but by similar techniques involved, there are not many attempts to bring the researchers from both disciplines together. It was the idea of the workshop to do so and to find out where a fruitful interplay might take place. Both disciplines cover a large variety of different subfields and only several typical examples could be presented. The workshop was attended by more than 40 researchers for which many the nomination "rheologist" would not be very precise. It is rather the demand of other fields, mainly biology or biophysics, that need microrheology as a tool to characterize the viscoelastic properties of objects as small as single cells – or even less – if only specific parts of the highly inhomogeneous cell are investigated. These researchers are mainly interested in the interplay of physiological and mechanical functionality. Furthermore, the technique opens new insights in the fundamental processes of soft matter and a considerable interest of physicists and physio-chemists could be noted too. On the other hand microfluidics is mostly seen as a subfield of mechanical engineering. Here, even the flow or wetting behaviour of simple liquids in micro channels is not yet fully understood.

In most cases, the term microrheology refers to the measurement of the diffusion of small tracer particles. This is done either with more or less sophisticated videomicroscopic techniques or with dynamic light scattering. For the simple case of a Newtonian liquid the diffusion behaviour is given by the Stokes Einstein relation and the viscosity can be easily extracted. For the case of a viscoelastic sample the diffusion behaviour becomes more complex and one can use the so called generalized Stokes Einstein relation in order to determine the complex shear modulus. But, as many speakers pointed out, this involves a tedious data analysis with Fourier-Laplace transforms or the involvement of Kramers-Kroenig relations of the movement of micron

sized particles with a spatial resolution of a few nanometers only or less. Obviously, the results must be taken very carefully and the complete characterisation of the validity range of the method is still ongoing: A question about the meaning of measurements by use of thermal movement in non equilibrium systems raised a vivid debate. However, any other technique that is able to determine the viscoelastic constants of microscopic samples, e.g. for quantities of less than 0.1 ml, is microrheological. Approaches that include piezo based actuators or standard shear cells that are specifically constructed to deal with these small quantities and forces were presented on the workshop too.

Historically, it was the demand of analytical chemists that pushed the microfluidic technology. They were looking for advanced Lab-on-a-chip devices where small amounts of samples could be analyzed in a fast and integrated manner. The separation of biological macromolecules in a gel matrix is the classical example and still, the exact description of the electrokinetic fields and forces is a current research topic. Another almost yet historical example is the inkjet technology. More recently it is investigated how microfluidic devices could be used to produce specific products like, e.g., monodispers emulsions. And the rheology of these liquids becomes even more fascinating when strong interactions with the boundaries become important. A general question always is the significance of slip (or even "is there slip at all in Newtonian fluids?"). But the strong interaction with the boundaries might also introduce an alignment of macromolecules or electrical polarisation – issues that are of less relevance in standard rheological investigations.

The first day started with a talk about Microfluidics and Rheology – a view from both sides by Prof. Dr. P. Woias, Universität Freiburg, and the first session was contributed to the question of how the confinement by lateral boundaries might influence the dynamic behaviour of colloids and polymers. The next session was opened by Prof. Dr. A. Bausch, Technische Universität München, with an introduction into the microrheology of Actin Networks. Together with the next session and its key note speaker Prof. Dr. C. Schmitt, Vrije Universiteit Amsterdam (Active and passive mircrorheology in Equilibrium and Non-Equilibrium materials) the rest of the day gave broad overview over microrheological applications for biophysical investigations. After the general meeting of the German Rheological Society, an evening reception took place in the historical environment of the botanic garden of the castle of Karlsruhe. It was an excellent opportunity for the scientists from the various different fields to get into closer contact and to discuss possibilities of future interactions or even cooperations. The next day first speaker was Prof. Dr. S. Hardt, Leibnitz Universität Hannover, with a talk about Flow regimes in micro- and nanofluidic devices. After this microfluidic session Prof. Dr. F. Scheffold, Université de Fribourg, gave an instructive introduction into Diffusive Wave Spectroscopy based optical microrheology. The workshop ended with the presentation of more "classical" rheological techniques that were extended to the micron scale and the last key note speaker was Prof. Dr. C. Clasen, University of Leuven with a presentation on micro "bulk" rheometry of complex fluids.

The workshop was appreciated by all attendees as a great success and many were surprised about the variety and broadness of the subject. It became obvious that microrheology and microfluidics are about to become established technologies, but both fields still demand the cooperation of interdisciplinary work groups for further development.

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Dr. Thomas Pfohl while his talk Self-Assembly and Alignment of Biomaterials in Microfluidic Environment

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