# RHEO-SAS: SMALL-ANGLE-SCATTERING TECHNIQUES USED IN COMBINATION WITH RHEOLOGY

**J. Laeuger, P. Heyer**

Anton Paar GmbH

joerg.laeuger@anton-paar.com

In order to understand the behaviour of complex fluids under flow it is necessary to pay special attention to structural changes that occur at the micro-structural level. This goal can be achieved by using small angle scattering methods implying neutrons, X-ray as well as light radiation. For characterization of materials in the mesoscopic scale techniques like Small Angle X-ray Scattering (SAXS) or Small Angle Neutron Scattering (SANS) are often employed. Suitable for structure investigations in the micrometer-size range simultaneously with rheological measurements is Small Angle Light Scattering (SALS).

The main advantages of the Rheo-SALS device are the optical quality with a telecentric optics which focuses the scattered light directly onto the CCD chip of the camera, the large scattering angle range from 0.5° - 25° and its pre-aligned and compact design. It is possible to move the laser to various positions along the radial direction of the optical transparent measurement geometries. Rotatable polarizers in the primary beam and the scattered light allow the measurement under all four polarization conditions which are possible in SALS under flow. Different temperature control systems based on Peltier or electrical heating over a measurement range from -40°C up to +300°C are available. For evaluation the Rheo-SALS setup different samples such as polymer blends, surfactant solutions or liquid crystals have been investigated. For all samples structural changes can be associated to a change in the rheological behavior indicating the benefit of such a combined technique.

In contrast to Rheo-SALS, SANS-experiments can not be performed in a normal laboratory. A neutron source, i.e. a reactor or a spallation source, and a SANS beamline are required. The Rheo-SANS setup is an accessory to the standard rheometer. The Rheometer together with the SANS accessory is put into the SANS beamline. Various geometries like concentric cylinder, parallel plate or an extensional fixture (SER) are possible. In the case of the concentric cylinder a tangential or a radial positioning of the neutron beam is possible, allowing the detection of the scattering in different planes with respect to the shear direction. The concentric cylinder geometries are made of either quartz glass or titanium. Special care has been taken on the alignment of the system and a solvent trap in order to prevent evaporation effects. Results on different samples are discussed.

The SANS setup can be used for Rheo-SAXS applications as well. The only difference is that the material of the geometries is changed to polycarbonate. The thickness of the material at the positions where the x-rays pass is minimized in order to reduce absorption at the geometries.

Various techniques of Rheo-Small-Angle-Scattering (Rheo-SAS) such as Rheo-SALS, Rheo-SANS, and Rheo-SAXS are described. The presented results show that SAS is a very powerful method to be combined with rheology. Rheo-SAS devices on a standard rheometer allow a simultaneous determination of rheological properties by the rheometer and structural information by the SAS setups.