Anton Paar

::: Intelligence in Rheometry

Dynamic Optical Rheo Analyzer (DORA)

for measurements of flow birefringence and flow dichroism

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Birefringence

A laser beam traveling through a calcite crystal is split into the ordinary and extraordinary ray. Two spots of light occur at the other end. This effect, called birefringence, is a result of the different refractive indexes of the material depending on the polarization and propagation direction of the light. Birefringence only occurs in anisotropic materials, as for isotropic materials the refractive index is identical in all propagation directions. Birefringence is therefore an indicator for anisotropy.
Shear can induce anisotropy in materials which are isotropic at rest. Relaxed polymer molecules, for example, are optically isotropic but when they are sheared anisotropy occurs due to the orientation of the molecule in the flow direction. Similar mechanisms can be observed for protein fibrils and rod-like viruses (refer to Figure 1).

Dichroism

Some materials absorb more light in one incident plane than another, so that light beams progressing through the material become more and more polarized as they proceed. This anisotropy in absorption is called dichroism, or flow dichroism if the anisotropy is induced by shear. Liquid crystals are dichroic by nature. When they are sheared the dichroism is reduced due to the aligment of the structures (Figure 2).

The setup

The Dynamic Rheo Optical Analyzer (DORA) in combination with the Physica MCR 501 rheometer enables simultaneous measurements of flow birefringence and flow dichroism.
The determination of birefringence and dichroism requires measurements under different polarization conditions.
Shear induces fast structural changes in the sample, therefore a high modulation frequency of the polarization is required.
DORA incorporates three polarized lasers mounted at 0°, 45° and 90° with respect to the optical train. They are switched on and off in a row producing light of different polarization with a frequency of 2200 Hz. This polarized light travels through the sample, which is rheologically measured with a parallel plate or a concentric cylinder geometry. After passing through the sample the light is split into two beams. The first beam directly hits the detector for dichroism, whereas the second beam passes through a polarizer and a λ/4 plate and falls on the birefringence detector. This means that birefringence and dichroism can be measured at the same time.
The system can be temperature-controlled via a fluid circulator in the range from 10 to 80 °C.

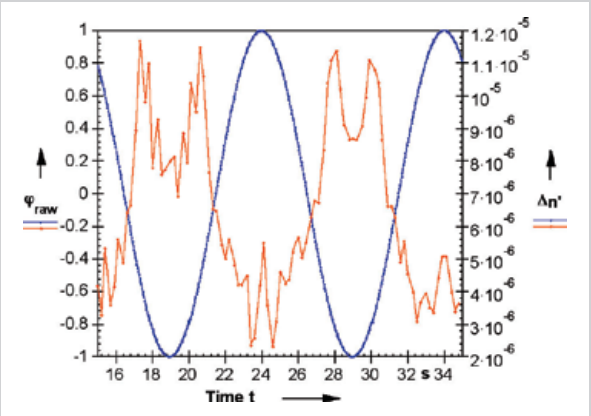
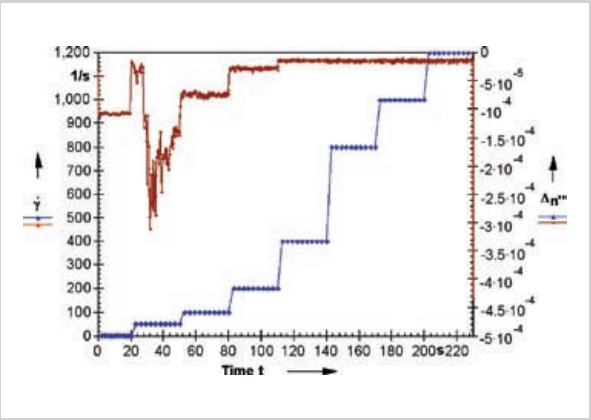


Figure 1: Polymer blend (1 % PiB in PDMS) in oscillation (0.1 Hz, Strain 1000 %). Normalized deflection angle (blue), birefringence (red)



Dichroism of a liquid crystal (black) at different shear rates (blue)

Specifications	
Dichroism (20 mm path length)	$1 \cdot 10^{-9}$
Birefringence (20 mm path length)	$2 \cdot 10^{-9}$
Laser wavelength	638 nm
Modulation frequency	2200 Hz
Min. measurement point duration	0.457 µs
Extinction	$3.6 \cdot 10^{-5}$
Retardation	$5.6 \cdot 10^{-5}$
Temperature range	10 - 70 °C
Parallel plate	43 mm
Concentric cylinder	33 mm, 1.5 mm gap

Features and benefits

- Rheological tests simultaneous with optical measurements
- Simultaneous measurement of dichroism and birefringence
- No moving or rotating parts
- Fast data acquisition due to high modulation frequency
- Parallel and concentric cylinder geometry
- Exclusively for MCR 501

Anton Paar® GmbH
A-8054 Graz, Anton-Paar-Str. 20
Tel.: +43 (0)316 257-0, E-mail: info@anton-paar.com
Fax: +43 (0)316 257-257, Web:www.anton-paar.com

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