„Free-standing smectic liquid crystal elastomer films“

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Summary

The submitted thesis represents the results of experimental investigation of the deformational behaviour of free-standing liquid crystalline elastomer films.

Previous experimental investigations of smectic elastomers deformation revealed two different types of deformational behaviour.

In one type of elastomers studied by Stannarius et al. deformation parallel to the smectic layer leads to the compression of the film perpendicular to the smectic layers, while in other smectic elastomers, usually the thickness of the film perpendicular to the smectic layer does not change when elastomers stretched parallel to the smectic layer plane.

In this thesis the first type of smectic elastomers has been studied in more details by different experimental methods; such as optical reflectometry, X-ray diffraction and polarized FTIR spectroscopy. The results of these experimental investigations can help to understand what is the reason for the two different types of deformational behaviour, why the elastomers studied by Finkelmann and coworkers show the in-plane fluidity behaviour, but in the case of the free-standing elastomer films studied in this thesis the dimensions of the film perpendicular to the smectic layer decrease during the stretching parallel to the smectic layers.

Elastic moduli of the smectic elastomer perpendicular to the smectic layers have been measured in experiments with free-standing elastomer balloons.

Elastic moduli parallel to the smectic layer have been measured by uniaxial stretching of free-standing elastomer films.

The elastic moduli parallel and perpendicular to the smectic layer have close values. The experimental values obtained by these two methods are not very precise because of inhomogeneity of the thickness of free-standing films and elastomer balloons.

Using optical reflectometry the compression of the free-standing smectic elastomer films during the stretching parallel to the smectic layers have been studied. These measurements have been done for the elastomer films prepared from LC a homopolymer and copolymers with different densities of crosslinking groups. Also the influents of the time of crosslinking on deformational behaviour have been studied. These experiments have revealed that, elastomers crosslinking for quite a long time, demonstrate behaviour similar to isotropic rubber with Poisson’s ratio $\nu = 1/2$. While elastomers with a short crosslinking time demonstrate the in-plane fluidity behaviour (there is no compression of the film perpendicular to the smectic layers) with Poisson’s ratio $\nu_z = 1$ for small deformations. These experimental observations indicate that, not only the chemical structure of the precursor LCP defines the properties of the obtained elastomer, but also preparation conditions play an important role.

Simultaneous optical reflectometry and small angle X-ray scattering measurements described in the section 5.2 have shown that during stretching of free-standing smectic elastomer films with layers parallel to the surface, the changes of the optical thickness are consistent with the measured changes of the molecular layer spacing. The compression of the film thickness is in a good agreement with the smectic layer compression derived from X-ray measurements, and with a compression of isotropic material with Poisson ratio close to ½. The maximal value of the layer compression induced by a mechanical deformation is about 30%.

The result of FRIR spectroscopy measurements have proved that the main mechanism of the smectic layer compression during the deformation parallel to the smectic layers is the interpenetration of the neighbouring layers. Experimental results show that stretching also induces a small tilt of the mesogens, but the value of the tilt angle is too small to be the main mechanism responsible for the compression of the smectic layers.