Peculiarities of mechanical and dielectric properties of a photoswitchable cybotatic-type nematic

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1. Introduction

Recently the liquid crystal displays (LCDs) technology, the main consumer of liquid crystalline materials, is constantly looking for new compounds with special physical properties. The discovery of novel types of mesogenic material, the so-called banana-shaped liquid crystals or bent-core liquid crystals (BCLCs), opened new possibilities in the field of liquid crystals. These newly discovered BCLCs materials exhibit polar order and chiral superstructures in their mesophases, although the molecules themselves are not chiral. Since then, a vast number of BCLCs exhibiting a great variety of interesting liquid crystalline phases have been synthesised and investigated. The presence of azo groups in bent-core mesogens structures allow to use reversible trans–cis isomerisation upon photoirradiation [1, 2]. Initially, these materials were considered to be of no use in LCDs industry because of their photosensitive nature. But today, the same phenomenon is the basis of their new applications. The combination of photosensitivity and liquid crystalline properties in the same molecule allows the material to be exploited for different applications in photonics such as optical data storage, photochemical molecular switches, polarisation holography, sensors and nonlinear optics.

2. Results and discussion

In this work, we demonstrate reversible photomanipulation of the elastic constants in azobenzene-containing bent-core liquid crystal incorporating 4-cyanoresorcinol as the central core unit. In addition to the columnar phase, the liquid crystal exhibits the nematic phase with unusually large splay elastic constant and low bent elastic constant. The nematic and columnar phases were studied by dielectric spectroscopy in the frequency range 10 Hz–10 MHz in cells with planar and homeotropic alignment. Using electro-optic and dielectric studies, we show the presence of the sign inversion of dielectric anisotropy. The SHG activity both in cybotactic nematic and in isotopic phases near clearing point was detected. We show reversible photomanipulation of the mechanical properties where the splay elastic constant decreases five-fold under the action of UV. The effect of UV is readily seen on the rheological properties of the liquid crystal. This behaviour cannot be explained by steric considerations only, and presumably results from the clustering.

3. Conclusion

The results of the investigation of the asymmetric bent-core liquid crystalline materials containing 4-cyanoresorcinol as the central core unit and azobenzene-based wings showed the linear changes of relaxation processes in nematic phase and columnar phase, demonstrating the high-frequency and low-frequency process with an activation energy of about 0.44 eV and 0.49 eV respectively. In cybotactic nematic an activation energy was almost twice smaller. It is related to changes and reorganization in the LC structure after N_{CybC}/Col_{rec} transition. We also observed the sign inversion of dielectric anisotropy in nematic phase explained by the formation of cybotactic nanoclusters and the presence of conformers that are allowed by flexible core of bent-core. The elastic anomaly $K_{33}<<K_{11}$, characteristic to bent-core mesogens, could be used in applications where low elastic constants are required. The presence of azobenzene wings in the mesogens under study makes it possible to manipulate the elastic properties by UV light. Besides fundamental studies of the phase structures reported herein, the trans-cis photoisomerization of the azobenzene wings provides additional possibilities and leads to interesting perspectives for the modification of the phase structure, polar order and chirality with these new bent-core mesogens by interaction with circular polarized light.

4. Acknowledgements

The authors acknowledge the support by the Deutsche Forschungsgemeinschaft (Projects ER 467/8-2 and TS 39/24-2).

5. References

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