Lyotropic chiral smectic C liquid crystal with polar electro-optic switching

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Thermotropic and lyotropic liquid crystals share a common state of matter with many overlapping features such as phase structure and symmetry. For example, the thermotropic smectic A phase (SmA) has a well-known analogue in lyotropics, the so-called lamellar Lα phase. Therefore, it is quite astonishing that there are only very few reports on the existence of a lyotropic analogue to the thermotropic smectic C (SmC) phase. Furthermore, so far there has been no report on a chiral lyotropic SmC* phase, which is expected to show macroscopic chirality effects such as helicity and ferroelectricity.

In this work we now present the first example of such a chiral lyotropic SmC* phase and proof its existence with several independent methods, including observation of characteristic textures, single domain X-ray diffraction, pitch lines, surface stabilization and polar electro-optic switching. For a general understanding of this new lyotropic phase, concentration and solvent dependent measurements of tilt angle and layer thickness were carried out. To clarify how chirality is communicated between the smectic double layers across the intermediating layers of achiral solvent molecules, we studied the helical pitch in dependence of temperature and solvent concentration. Most surprisingly the helical twist increases with increasing solvent concentration and thus increasing thickness of the inter-lamellar solvent layer. To explain this quite counter intuitive behavior we suggest a tentative model of this lyotropic lamellar tilted phase. Furthermore, we observed that the lyotropic SmC* analog phase shows polarity dependent electro-optic switching in analogy to the thermotropic ferroelectric phase (Fig. 1). Switching times were determined to be in the range of a few milliseconds. Spontaneous electric polarization was estimated from these switching times to be in the order of magnitude of $10^{-1}$ nC·cm$^{-2}$.

Fig. 1: Electro-optic switching of surface stabilized lyotropic SmC* (**Lα***) domains.

In conclusion, we provide proof of principle that the chiral SmC* phase can exist in lyotropic liquid crystals and exhibits pronounced chirality effects analog to those of the thermotropic phase. Furthermore, we started to elucidate the particular chirality transfer mechanisms of this novel phase, which we suggest to be denoted as L**α***

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