Director/Barycentric rotation in cholesteric droplets under temperature gradient

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In the cholesteric (Ch) phase, director rotates when temperature gradient is applied along its helical axis. This phenomenon is called Lehmann rotation, and its rotational mechanism is explained by the Leslie’s theory phenomenologically [1]. However, this phenomenon is poorly reproducible; the experimental verification for the Lehmann rotation isn’t enough yet. In this situation, recently, Oswald et al. found the stripe texture in the droplet formed by the Ch phase (Ch droplet) rotates under the temperature gradient in the coexistence region of the isotropic (I) and the Ch phase [2]. However, the experimental and the theoretical analysis for this phenomenon isn’t enough yet, so that it is still a question whether its rotational mechanism can be explained by the Leslie’s theory or not. Therefore, in this study, to clarify the rotational mechanism, we analyzed the physical properties of the rotation in the Ch droplets using the polarized microscopy and flow-field measurements with the fluorescence photo-bleaching method.

In this study, we made the cholesteric liquid crystalline samples, adding the chiral dopant R811 (Merck) into the nematic liquid crystalline mixture of 5CB and No.270032 (LCC). The phase sequence of this sample was Ch-54C-I+Ch-58C-L, which is almost independent of the concentration of the R811. Making the Ch droplets in the coexistence region of the I and the Ch (I+Ch) phase in this sample, we found the two types of droplets with stripe and concentric-circle (CC) texture appear as shown in Fig.1 (stripe and CC-type droplets). Furthermore, rotational motions are induced in these two types of the droplets under the temperature gradient. To analyze the physical property of these heat-driven rotational motions, we measured the chirality dependence of the rotational speed of these motions. In this study, we evaluated the speed using the conversion efficiency \( \omega V T \) from the temperature gradient VT to the angular velocity of the rotation \( \omega \). As shown in Fig.2, in the CC-type droplets, the efficiency increases as the concentration of the R811, that is, the chirality increases; this property is consistent with the Lehmann rotation. On the other hand, in the stripe-type droplets, we found the conversion efficiency decreases as the chirality increases in contrast to the Lehmann rotation.

To analyse the physical properties of these heat-driven rotations further, we measured the flow-field of the system using the photo-bleaching method. As a result, we found the rotational flow according to the rotation of the texture is induced in the stripe-type droplet, while the director rotation is dominant in the CC-type droplet as well as the Lehmann rotation. Therefore, we concluded the heat-driven rotational motion in the CC-type droplet can be explained by the Lehmann rotation, and the motion in the stripe-type droplet is a barycentric motion of each molecule in the droplet, which cannot be explained by the Lehmann rotation.

References

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