Highly-efficient Lehmann rotation in topological droplets in cholesteric dispersion

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In the end of the 19th century, Otto Lehmann first found the rotational motion in a chiral liquid crystal under the application of thermal gradient. These days, similar rotational phenomenon has been reported for the cholesteric (Ch) droplets in the coexisting region of Ch and isotropic (Iso) phases subjected to temperature gradient [1, 2]. Interestingly, the rotational speed, i.e. conversion efficiency, depends on the relative direction of the Ch helix with respect to the direction of the thermal gradient. Thus, the rotation would be driven by some kind of flow propagating in the helical director structure, like a mechanical turbine.

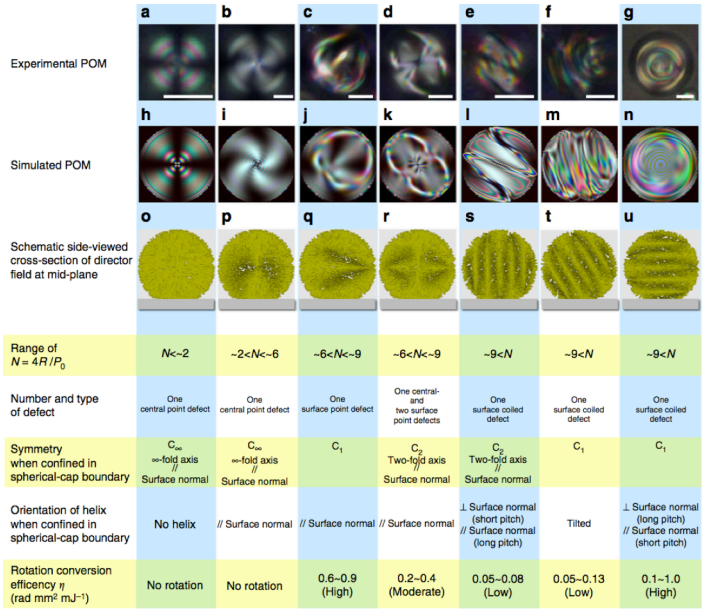

Figure: Topological types of Ch droplets formed in dispersion and their characteristics in Lehmann rotation.

In this study, we succeeded in realizing the Lehmann rotation in dispersion, where the Ch droplets are suspended in a fluorinated solvent with weak homeotropic anchoring. In such a case, topological diversity appears as seven different types (see Figure) as has been already known [3]. However, amazingly, the rotational conversion efficiency strongly depends on such topological types [4]. Moreover, in some cases, the rotational speed becomes far faster than those observed in the previous studies. In addition, our strategy well works to stabilize the rotational phenomenon itself. We also simulated the internal director field in these droplets to discuss the relationship between the structure and the rotational behavior.

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[2] Yoshioka, J., Ito, F., Suzuki, Y., Takahashi, H., Takizawa, H. & Tabe, Y., Director/ barycentric rotation in cholesteric droplets under temperature gradient. Soft Matter 10, 5869, (2014).
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[4] Yoshioka, J. & Araoka, F. Topology-dependent self-structure mediation and efficient energy conversion in heat-flux-driven rotors of cholesteric droplets. Nat. Commun. 9, 432, (2018).