Non-equilibrium dynamics of 2D liquid crystals driven by transmembrane gas flow

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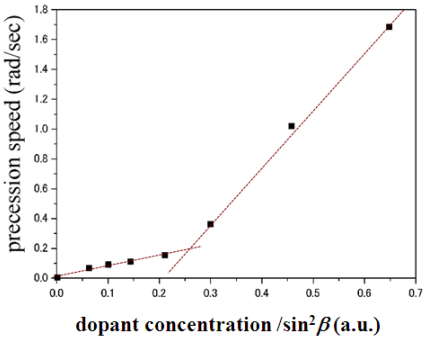
1. INTRODUCTION

In chiral liquid crystals, the lack of mirror symmetry can connect un-conjugated forces and fluxes, which results in a rotational torque on LC molecules induced by an electric, a heat or a diffusion current. In early studies, people considered long-range helical order necessary for the cross coupling, but recent experiments showed that the flow-driven molecular rotation takes place also in monolayers[1] and compensated cholesteric samples[2], indicating that the phenomena should be understood at molecular-level. Cross effect has attracted people's attention in various systems such as ferroelectric, ferromagnetic, biological materials, and in this work we try to elucidate the molecular-level mechanism of the cross coupling in chiral liquid crystals.

2. Experiment and result

In the macroscopic model proposed by Leslie[3], the rotational efficiency should be linear to the macroscopic chirality. The macroscopic chirality, when the chiral dopant is not much, can be represented by the dopant concentration. By using achiral LC compound mixed with chiral dopant, we measured the precession speed of the c-director of free-standing films under transmembrane methanol vapor transport, with changing the dopant concentration. The result is shown in Fig.1. Obviously, the relation is not linear, showing a clear contrast to the fact that the helical pitch in cholesteric phase of the same sample is perfectly in inverse proportion to the dopant concentration. The data suggests that the dynamical coherent length can be much shorter than the static one.



Figures 1: Dependence of rotational speed of LC molecules on dopant concentration (normalized by molecular tilt). Transferred material is methanol vapor.

It should be also pointed that the sample composed of 100% chiral molecules does not show the higher rotational efficiency than the mixture of achiral and chiral compounds. In order to cause the collective LC rotations by mass transport, all the molecules should not possess the rotary function. Instead, the efficiency becomes higher when the achiral molecules coherently enhance the unidirectional motion of small amount of chiral molecules mixed with them. The result shows the cooperative LC nature plays an essential role.

REFERENCES

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