Spontaneously polar or/and twisted liquid crystal structures

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In nature, helical structures are widespread and manifest across a range of scales, spanning from nanometres to macro scales. Helices are often formed by biological polymers, such as DNA or collagen, and their formation is attributed to the twisted assemblies of chiral molecules, stemming from the asymmetry in the arrangement of neighboring components. However, it is noteworthy that helices are not exclusively linked to molecular-level chirality.

Liquid crystals, specifically the twist-bend phases (nematic and smectics), composed of achiral bent dimers or rigid bent-core molecules, have been recognized for several years. The short helices observed in these phases are attributed to a reduction in bend elasticity resulting from the distinctive molecular shape. While the twist-bend nematic phase exhibits a relatively simple structure with a single short helix, smectic phases have been observed to form a double helix, with a longer helix superimposed on a shorter one [1]. Also more intricate multi-helical structures have been identified.

Our recent research has unveiled also a ferroelectric analogue of the N_{TB} (polar twist-bend) phase, comprising molecules with strong dipole moments [2].

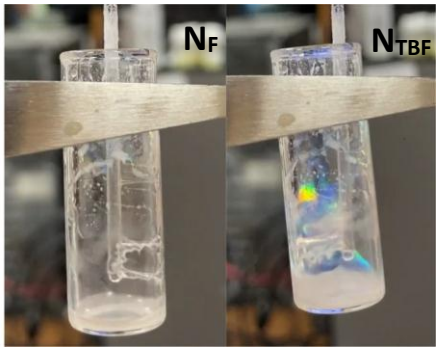

Fig. 1 Phase transition form N_F to helical N_{TBF} phase

The spontaneous helix in the polar N_{TB} phase is significantly longer than in its apolar counterpart, resulting in selective light reflection in the visible range (Fig. 1). Despite its similarity to the heliconical non-polar twist-bend nematic phase, the genesis of this novel liquid crystalline phase differs. It emerges due to electrical interactions that induce a non-collinear orientation of electric dipoles, resembling the observed behavior of spins in magnetic systems. Considering that the Dzyaloshinskii-Moriya interaction generates a diverse array of chiral topologies in magnetic spins, such as helical or skyrmion phases, one may pose the question of whether an analogous interaction of electric dipoles may lead to similar structural complexity.

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