

Laboratory of Soft Matter: Liquid Crystals Group

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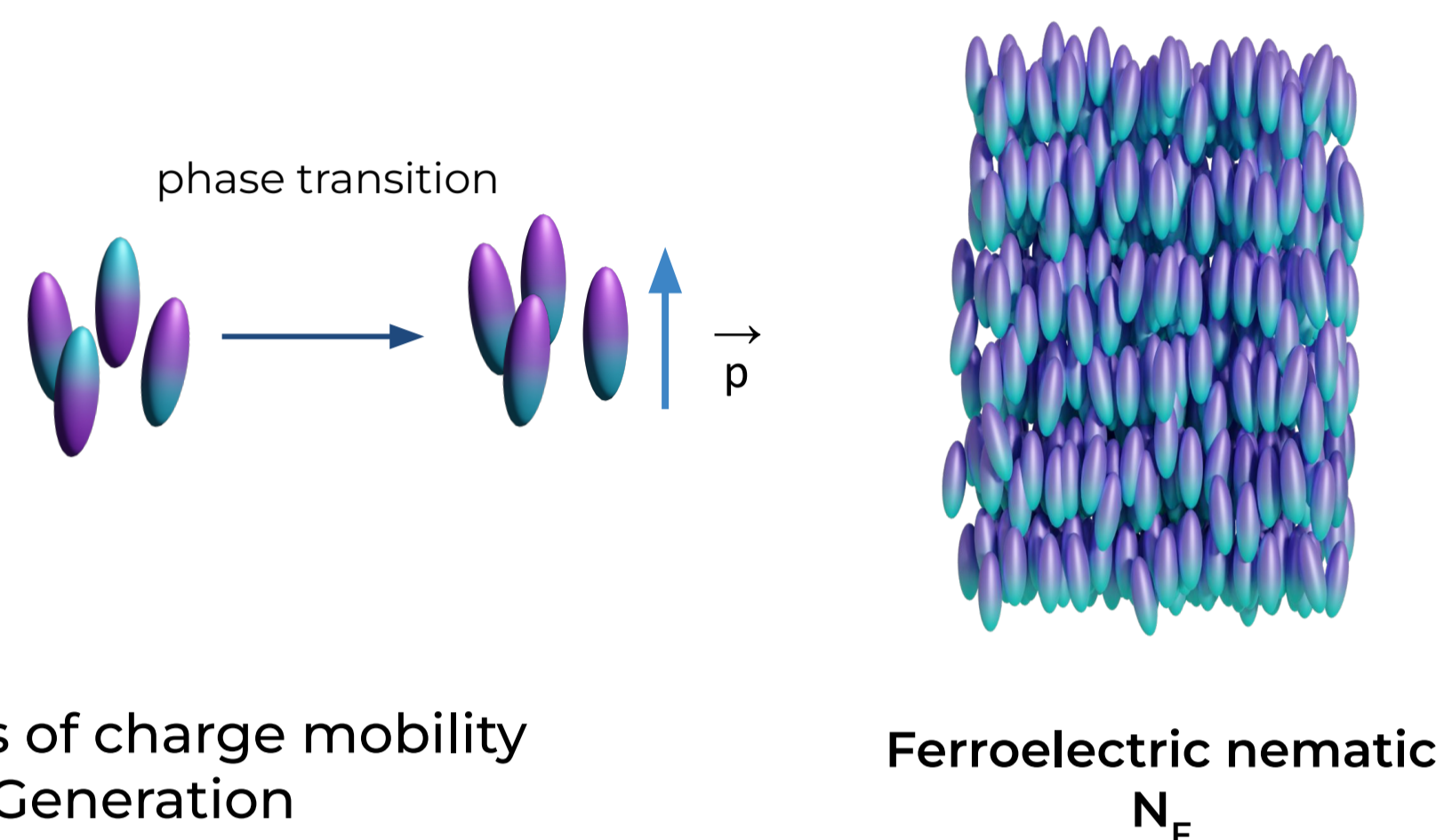


Main research focus: Polar order in soft matter

Ferroelectricity arises in liquid crystals when molecules with strong dipole moments align collectively, manifesting as macroscopic spontaneous polarization. Our work seeks to expand the library of ferroelectric LCs and establish the fundamental principles for designing polar order.

Research methods used:

- X-ray diffraction and small angle x-ray scattering
- AFM imaging
- Optical polarizing microscopy
- Differential Scanning Calorimetry
- Dielectric spectroscopy
- Spectral reflectance
- Circular dichroism
- ToF measurements of charge mobility
- Second Harmonic Generation
- Polarization measurements



International collaboration:

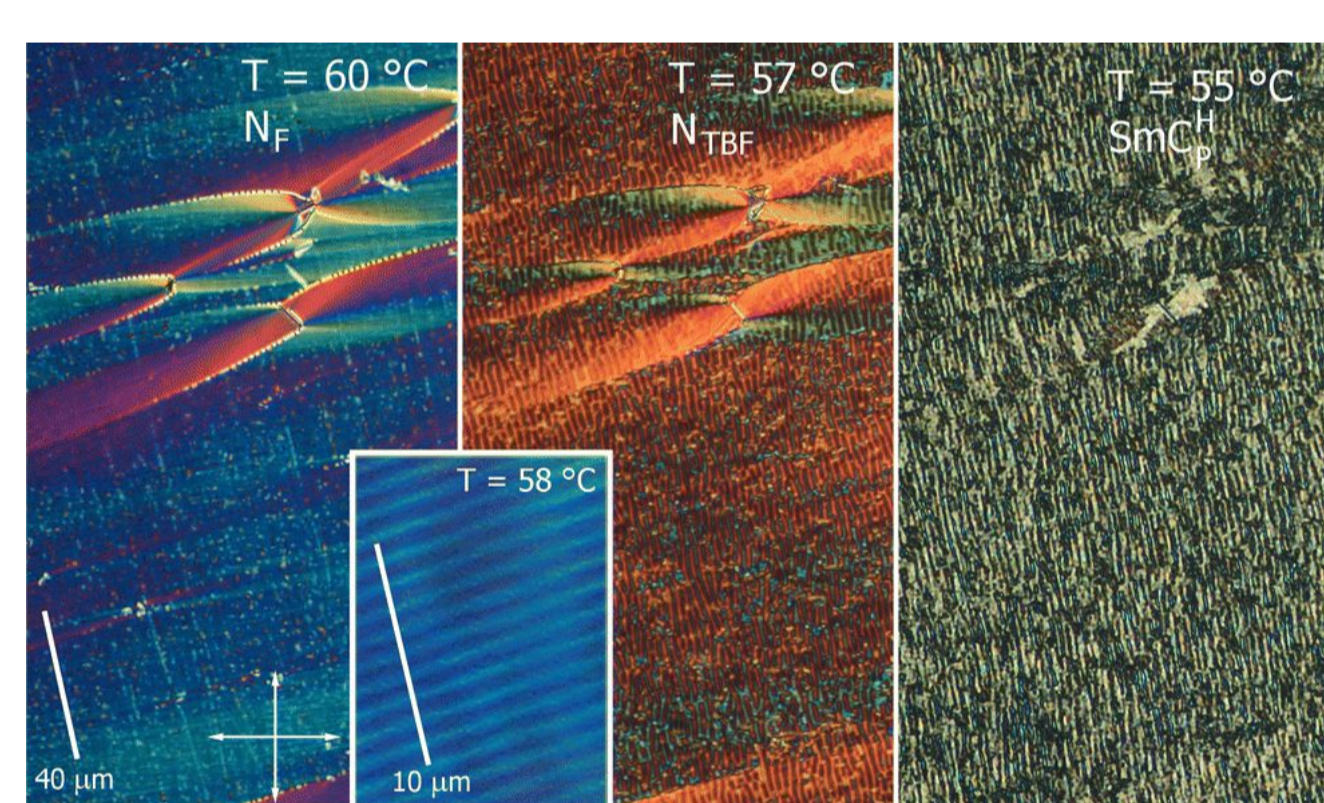
Massachusetts Institute of Technology,
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Middle Tennessee State University
Lawrence Berkeley National Laboratory
Brookhaven National Laboratory
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Spontaneous helix formation in a polar smectic phase

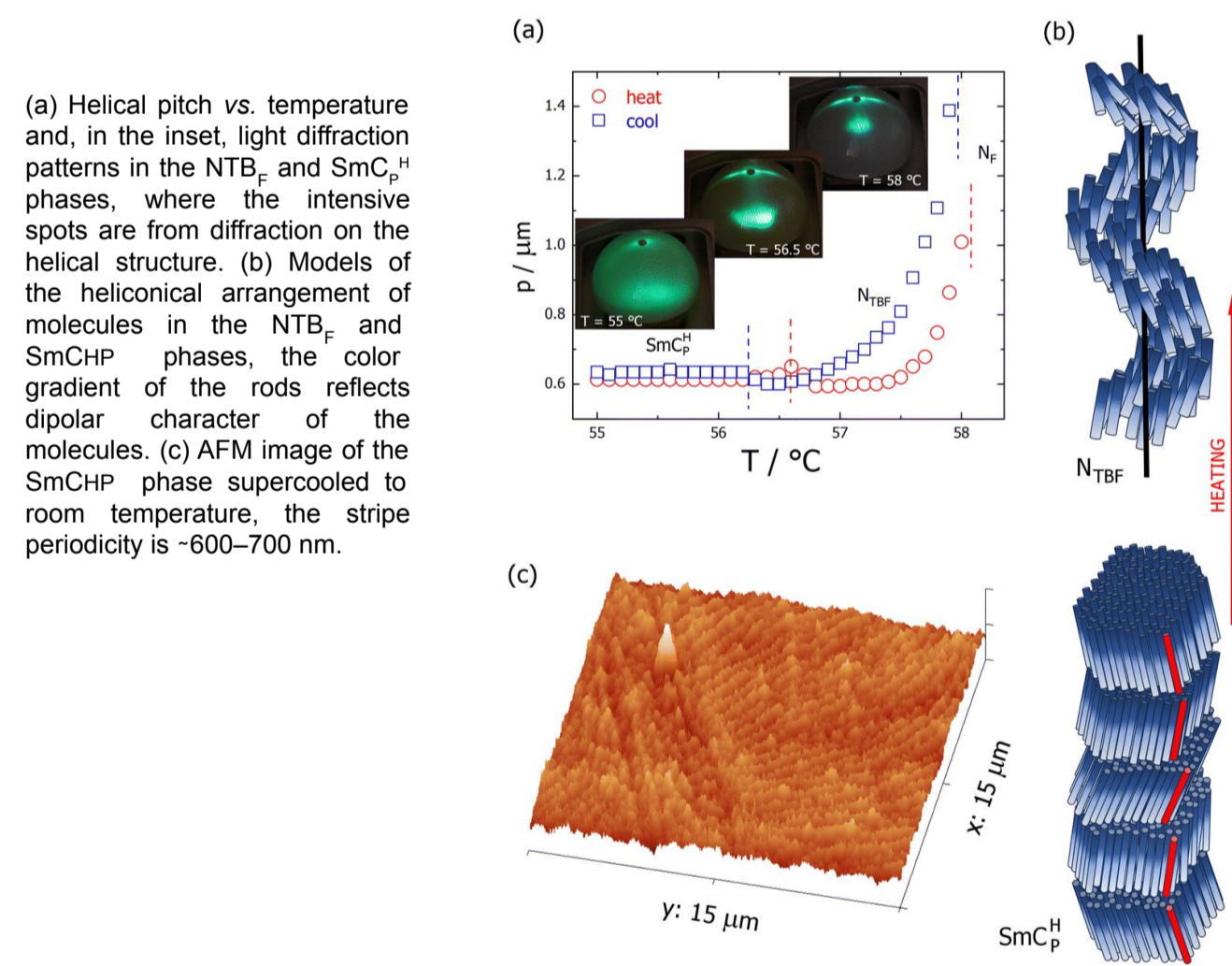
Materials Horizons

E. Górecka, M. Majewska, L. Fekete, J. Karcz, J. Żukowska, J. Herman, P. Kula, D. Pocięcha

In soft ferroelectric crystals, the depolarization field can be reduced by a periodic distortion of the polarization direction. In the polar nematic and tilted smectic phases, this process is energetically favored, as it only requires changes in the director orientation. We demonstrate the spontaneous formation of a helical structure in the proper ferroelectric tilted smectic (SmC_p^H) phase, formed below the heliconical polar nematic (NTB_p) phase. The helical pitch in the smectic phase is approximately 600 nm and remains nearly constant across the entire temperature range of the phase. Under weak electric field, the helix reorients while its structure remains largely intact; however, in stronger field the helix is destroyed as the electric polarization aligns along the electric field.



The textures of the NF, NTB and SmC HP phases in a 3-µm-thick planar cell with parallel rubbing direction, the periodicity of the stripes visible in the images of NTB and SmC HP is dependent on the cell thickness.

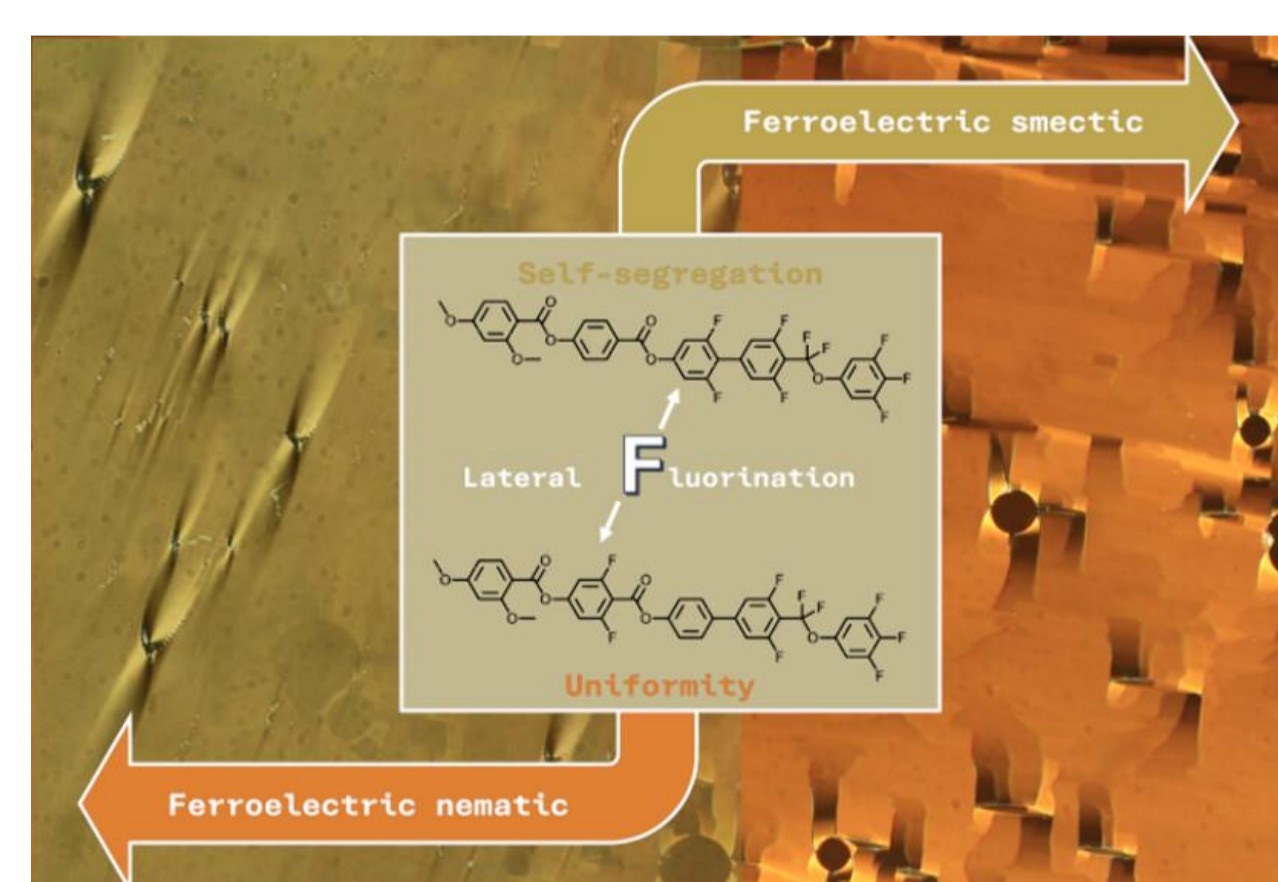


Fluorination: Simple Change but Complex Impact on Ferroelectric Nematic and Smectic Liquid Crystal Phases

Journal of the American Chemical Society

G. J. Strachan, E. Górecka, J. Hobbs, D. Pocięcha

A series of liquid crystal (LC) materials are reported, which form a variety of ferroelectric nematic and smectic phases. The relationship between the number and position of lateral fluorine substituents and the formation of ferroelectric LC phases is investigated. While the addition of fluorine substituents increases the temperature at which ferroelectric order appears, the relationship between fluorination and the LC phase sequence is more complicated. Introducing lateral fluorine substituents can either suppress or promote the formation of ferroelectric smectic phases, depending on their position within the molecule, and the interplay between these trends allows for more exotic ferroelectric phases to appear.



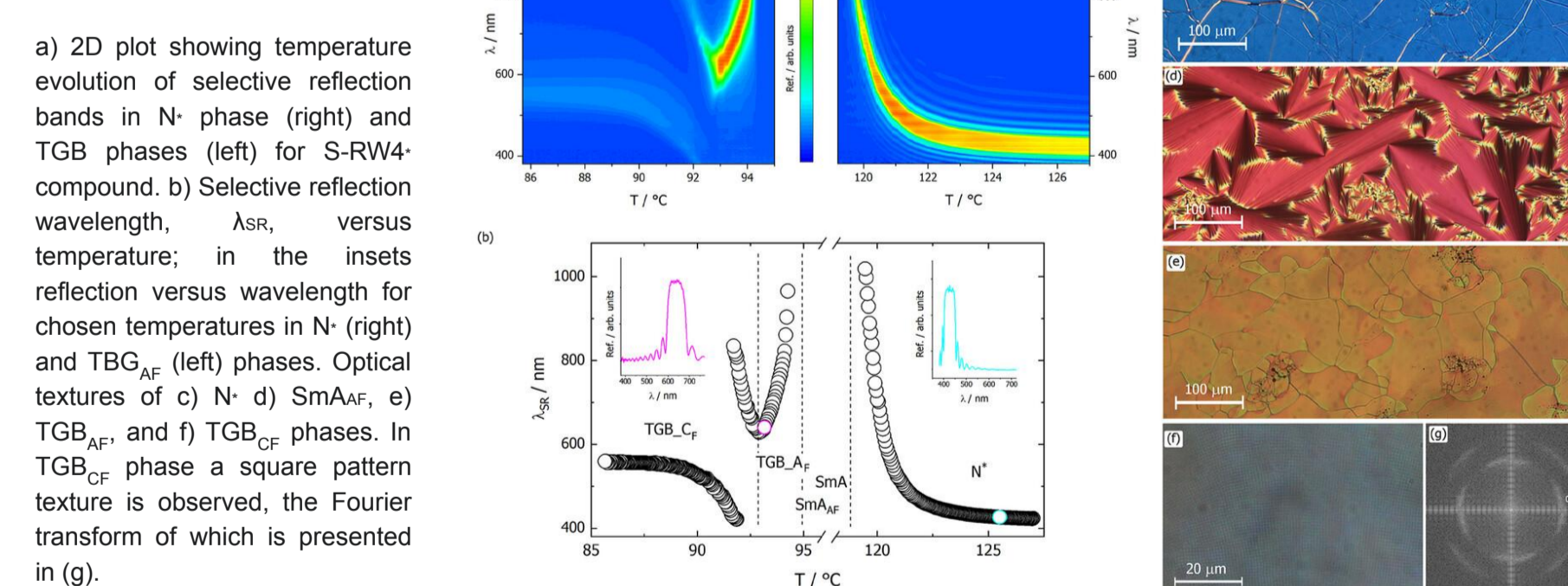
Schematic drawing of the structure of (a) paraelectric (N) and ferroelectric (N_F) nematic phases, (b) ortho ($SmAr$) and tilted ($SmCr$) ferroelectric phases, and (c) heliconical ferroelectric nematic phase, N_{TB} . P is the electric polarization vector resulting from the parallel orientation of strongly dipolar molecules.

Twist Grain Boundary Phases in Proper Ferroelectric Liquid Crystals Realm

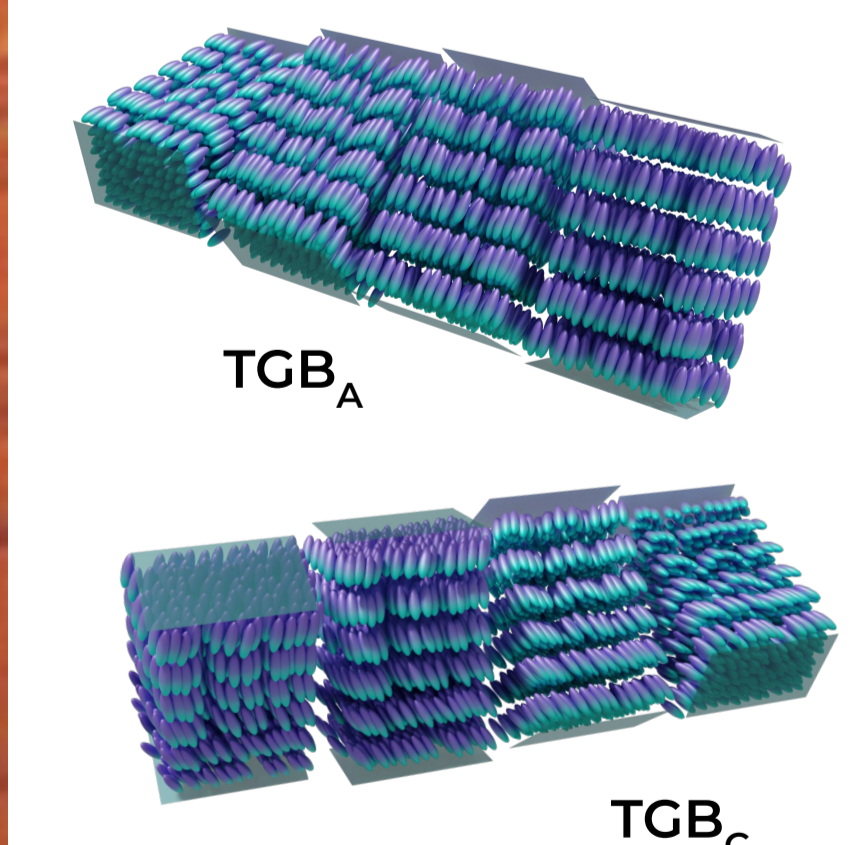
Advanced Science

D. Pocięcha, J. Szydłowska, N. Vauptič, K. Kwiatkowska, M. Juodka, J. Spiess, J. M. D. Storey, C. T. Imrie, R. Walker, E. Górecka

The twist-grain-boundary (TGB) phases, characterized by a periodic, helical arrangement of blocks made of polar smectic phases, SmA_F and SmC_F , have been discovered. They are observed for rod-like molecules with a strong longitudinal dipole moment, featuring an (S)-2-methylbutyl end group having only weak twisting power, and emerge below the antiferroelectric SmA_{AF} phase, where the lamellar structure is already well established. It is suggested that the structure is governed by electrostatic interactions amplified by weak chiral forces, in striking contrast to the mechanism of TGB phase formation found in non-polar materials. The TGB phases exhibit selective light reflection in the visible range, while the value of electric polarization confirms an almost perfectly ordered dipole alignment.



Twist Grain Boundary phases



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