Self-assembled liquid crystal architectures for soft matter photonics

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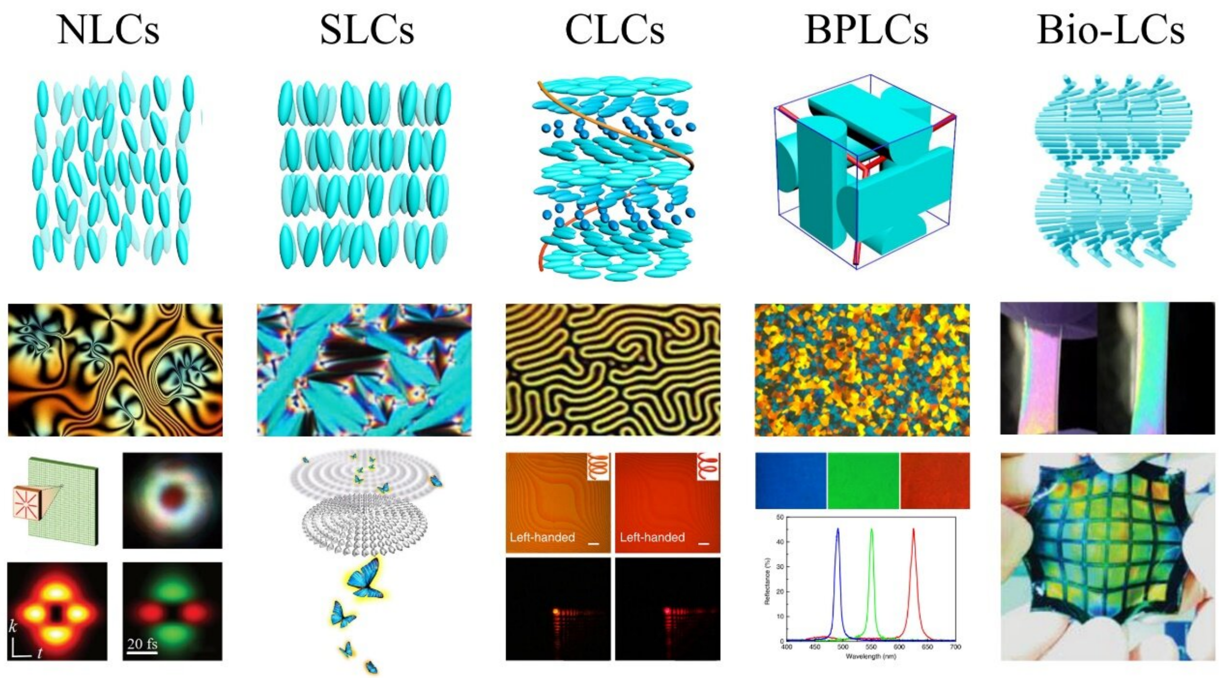

Schematic configurations, representative textures, and promising applications of nematic phase LCs, smectic phase LCs, cholesteric phase LCs, blue phase LCs, and bio-based LCs. Credit: Ling-Ling Ma, Chao-Yi Li, Jin-Tao Pan, Yue-E Ji, Chang Jiang, Ren Zheng, Ze-Yu Wang, Yu Wang, Bing-Xiang Li, Yan-Qing Lu

"Soft matter" was first proposed by Pierre-Gilles de Gennes in his Nobel acceptance speech in 1991. The term describes materials between aqueous substances and ideal solids.

Soft matter materials with a wide variety of complex configurations, colorful patterns, metastable states, and macroscopic softness have provided valuable inspirations for addressing modern challenges in both optics and photonics. Self-assembled liquid crystal (LC) represents one of the most attractive soft matter systems. Its microstructures exhibit superior properties of easy fabrication, fine tunability, high flexibility, and remarkable stimuli-responsiveness.

Over the past years, optical systems based on LCs (typical thermotropic and bio-based lyotropic LCs) have experienced a booming development, promoting the emergence of new phenomena, functions, and applications. As such, it is of increasing importance to discuss recent advances of LC-architectures-based soft matter photonics (Soft Mattonics) from a comprehensive perspective to provide valuable reference for future development of the relevant realm.

In a new article published in *Light: Science & Applications*, a team of scientists, led by Professor Yan-Qing Lu from the National Laboratory of Solid State Microstructures, Key Laboratory of Intelligent Optical Sensing and Manipulation, and College of Engineering and Applied Sciences, Nanjing University, China, and co-workers have conducted a systematic and comprehensive review to bridge various dynamically tunable LC architectures with their diverse applications in Soft Mattonics.

In this paper, the basic definitions, physical properties, manipulation schemes, and dynamic controllability of typical thermotropic LCs and bio-based lyotropic LCs are described in detail, including nematic phase LCs, smectic phase LCs, cholesteric phase LCs, blue phase LCs, and celluloses.

Microstructures bridge the inherent properties of nanomaterial and the important functionalities, playing a significant role in developing ideal

LC-based optics and photonics. To control LC microstructures, at one end of the spectrum is the creation. It can be achieved by combining "top-down" manufacturing technique with "bottom-up" self-assembly process of LCs.

For example, substrates with 3D topographic surface patterning can be employed to generate ordered topological defect arrays; the 2D photoaligned layer triggers a flexible construction of 3D LC superstructures. At the other end of the spectrum is the elaborate tunability of LC architectures. Many efforts have been devoted to this field to dynamically manipulate the LC structures, by introducing heat, electricity, light, stress, and magnetic fields.

With the presented work, Lu and co-workers provided an overview of LC-based devices in the rapidly growing field of Soft Mattonics, including smart displays, optical imaging, light field modulation devices, soft actuators, and smart windows. It brings attractive, tunable, efficient and multiple functionalities/performances to the soft-matter-based optical platforms. These scientists also highlighted both challenges and opportunities of these materials towards the soft matter photonics:

1. Large-scale production and processing;
2. Achieving optimized "structure-property-function" relationships;
3. Combining LCs with other soft materials;
4. Seamless integration of soft matter materials with existing optical components;
5. Integrating LCs with cutting-edge electronic and robotic systems;
6. Newly discovered LC phases.

Further exploration of this topic would not only broaden the knowledge of Soft Mattonics, but also encourage multidisciplinary research from specialists across different disciplines and promote diverse soft and smart photonic applications.

More information: Ling-Ling Ma et al, Self-assembled liquid crystal architectures for soft matter photonics, *Light: Science & Applications* (2022). DOI: 10.1038/s41377-022-00930-5

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