**BOOK REVIEW**

**Liquid crystals with nano and microparticles**, edited by Jan P. F. Lagerwall and Giusy Scalia, Singapore, World Scientific, 2017, 2 volume set, 920 pp., £328 ($435, 370 Euro) (hardback), ISBN: 978-981-4619-25-7

The book addresses complex configurations and superstructures emerging from interactions between liquid crystal (LC) phases and immersed nano- or microparticles. Its content merges two classical soft condensed matter research fields, i.e. LCs and colloids, into a new combined area coming to the spotlight in the current decade.

Nanoparticles covered in the book refer to particles which possess at least one characteristic length in the nanoscopic (1 nm to sub-micrometre) regime. Therefore, one-dimensional carbon nanotubes or two-dimensional graphene plates, which have typically one characteristic length far beyond the nanoscopic range, are also members. Microparticles refer to inclusions where all characteristic sizes are in the micrometre or supra-micrometre range. The coupling between particles and LC host depends on the characteristic linear size \(R\) of particles, their geometry, and wetting and anchoring interactions at the LC–particle interface. The complexity of phenomena could be further increased by specific surface treatment of particles in order to avoid phase separation or to obtain desired anchoring conditions. On decreasing \(R\), the LC particle coupling strength decreases. In case of large enough value of \(R\), particles could strongly modify surrounding orientational LC ordering and can even trigger onset of topological defects in LC medium. Consequently, particles could strongly mutually interact via elastically distorted LC medium, where the character of interactions could be controlled (e.g. by geometry of particles and/or surface anchoring conditions). On the contrary, small enough particles could act effectively as dilutions. In this case, they could also stabilise topological defects by entropy driven mechanism. Namely, they tend to assemble within cores of defects, reducing their condensation free energy penalty. Complexity of LC–particle interactions enables generation of qualitatively new effective configurations and effective materials, promising to open gates to several new applications, in particular in photonics and nano-related devices. Such systems could be also exploited as adequate experimentally accessible and controlled playground of fundamental physics.

The book consists of contributions written by internationally recognised leaders in the field. The overall book content is excellently coordinated by J.P.F. Lagerwall and G. Scalia to form a synchronised story, interesting to broad scientific audience.

The book is conceptually divided into five distinct parts and has in overall 27 chapters. The first part introduces fundamental concepts of the field to the beginners. It focuses to phenomena that are presented in the book. An overview of colloids and thermotropic and lyotropic LCs is given. Basic theory of colloids is presented focusing to the concepts supporting the content of the book. Dispersion stability of spheres, rods and discs is analysed. The theoretical description of liquid crystalline ordering in presence of inclusions is presented.

In the second part, efficient methods for studying inclusions in liquid crystalline phases are introduced. Optical microscopy is presented, including both conventional and novel variations. Recent technological advances have resulted in a rich variety of new imaging methods accessing ordering and material properties with high resolution. Description of X-ray scattering and Raman spectroscopy follows. Manipulation of inclusions using optical tweezers is presented. Chapter on investigation of surface (used to confine and control LCs) topography by means of Atomic Force Measurements at nanoscale resolution closes the subtopic.

The third part deals with demonstrative examples of liquid crystalline – particle suspensions. It yields a brief overview of key studies of solid microparticles in bulk liquid crystalline phases. Structural and topological properties of 2D and 3D colloidal crystals of different symmetries are described. Inclusions in freely suspended smectic films are discussed. A chapter follows describing electrophoresis or electro-osmosis-enabled motion of particles in LCs.

The fourth part treats nanoscale guests in liquid crystalline phases. It introduces key synthesis schemes for metallic and semiconducting nanoparticles. It describes how particles could be coated with different types of ligands in order to avoid phase separation and to allow dispersion in thermotropic calamitic nematics. Impact of inclusions on electro-optic behaviour of nematic LC phase is shown. Mixtures of non-polymeric LCs with inorganic nanorods, gold nanoparticles and carbon nanotubes are discussed, followed by an overview of behaviour of carbon nanotube–doped elastomers. Phenomena enabled by magnetic or ferromagnetic character of particles are presented. Furthermore, impact of lyotropic LCs on nanoparticle dispersion and organisation is demonstrated. Capability of topological defects and strong local elastic distortions to assemble nanoparticles over macroscopic sizes is shown in smectic and cholesteric phases. Finally, controlled creation of polymer nanoparticles and networks via LC polymerisation are analysed.

The fifth part considers LCs formed by nanoparticle suspensions. The chemical composition, phase behaviour and structure of carbon nanotube–based LCs are...
presented. Description of nematic phase formation in suspensions of graphene oxides (GOs) follows. It demonstrates that competition between translational entropy for a long-range ordered phase and rotational entropy decides when the LC phase forms. Electric field effects on aqueous GO dispersions are reviewed. It is shown how the electro-optical sensitivity of dispersions is controlled. These effects could be used to fabricate GO LC devices similar to conventional LC displays. Colloid suspensions of pigments are discussed and their electro-optic properties are compared with respect to traditional dyed low-molecular-weight LC systems. It is proposed that mixtures of pigment suspensions with small amounts of ferrofluids could be exploited as promising magneto-optical materials. The book closes by presenting cholesteric LC formation in suspensions of cellulose nanocrystals. Aqueous suspensions could form cholesteric ordering already at relatively low concentrations. When dried into thin solid films, the periodicity of the helical structure can be tuned to the range of visible selective reflection.

To conclude, the book summarises the present knowledge in the field, introduces fundamental concepts to the beginners, describes key measuring methods and presents several different typical demonstrative systems, some of them exhibiting extraordinary rich spectrum of structures and superstructures. I am sure that with time the book will become attractor to a broad audience (physicists, chemists, material scientists, engineers, etc.), ranging from students, beginners in the field to experienced researchers. To summarise, this is the book that I have been missing in my bookshelf.