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Lyotropic liquid crystals make up one of the most outstanding examples of complex fluids based on components as simple as water, lipids, surfactants, platelets, and rodlike particles. These also are some rare cases in which complex fluids are spontaneously found at the thermodynamic equilibrium. What is then the driving force behind this unique self-organization? And how can the specific features of these resulting materials be exploited in the various disciplines of applied and fundamental sciences? This is a question of primary importance since the relevance of lyotropic liquid crystals spans today fields ranging from biology to nanotechnology, from cosmetics to food technologies. Despite their apparent simplicity, these materials remain challenging systems that need to be understood at the molecular level. Water, which is the most frequently used solvent in lyotropic liquid crystals, adds up dramatically to the complexity of the systems, as the hydrogen bonds among water molecules and the resulting clusters of water molecules, already provide this solvent most of the features common to structured fluids. When polar lipids are mixed with water, the selectivity in the partition coefficient of water with the hydrophilic and hydrophobic parts of the lipids leads to structured fluids of complex topologies and intricate architectures organized in the few nanometer-length scales. These heterogeneities and their organization determine to a very great extent the final properties of lyotropic liquid crystals and can then be exploited for encapsulation, templating, diffusion, release, reactions, or confinement in a multitude of possible applications.

Recently, researchers are devoting much of their efforts to better understand how to manipulate the lyotropic liquid crystals and to be able to increase the lattice parameter values, to elongate and to enlarge the aqueous channels in order to use these systems as solubilization reservoirs for food additives, supplements, bioactives, and drugs.

The modified lyotropic liquid crystals (LLCs) show very significant potential to serve as microreactors, template systems for interfacial crystallization, and more.

It is our believe that the recent progress made in the last decade will bring us to a new area in which LLCs will be used in the pharmaceutical, cosmetic, and food industries as major carriers of bioactives.

This book tackles the topic of LLCs from both the fundamental and applied perspectives. The first part of the book discusses our current fundamental understanding of lyotropic liquid crystals, with emphasis on lipid-based
systems and rodlike solvent dispersions, whereas the second part of the book tackles the applications landscape, with special emphasis on drug delivery applications.

In Chapter 1, Mezzenga describes the physics of self-assembly of lyotropic liquid crystals from a thermodynamic point of view, introducing recent concepts such as self-consistent field theory, to understand the structural and physical properties of these systems; the chapter also touches on the current understanding of transient states associated with order–order transitions.

Herrera and Rey, in Chapter 2, present a comprehensive review of the rheology and properties of nematic phases, including calamitic and discotic micellar solutions and wormlike micelles. Their review examines verifiable rheological liquid crystal models for lyotropic nematics highlighting the mechanisms that control orientation behavior under shear, anisotropic viscoelasticity, and non-Newtonian behavior.

In Chapter 3, Kolev, Aserin, and Garti focus on the topological properties of the columnar hexagonal phase and are critically looking at—and summarizing—the available theoretical and mathematical aspects and the most fundamental aspects of the columnar reverse hexagonal mesophase.

Chapter 4 by Hartley and Shen provides a comprehensive review of the available experimental characterization methods of lyotropic liquid crystalline systems, spanning small-angle neutrons and X-ray scattering, nuclear magnetic resonance, positron annihilation lifetime spectroscopy, electron and atomic force microscopy, and neutron reflectivity.

In Chapter 5, Yaghmur and Glatter discuss the phase diagram, emulsification procedures, structural and physical properties of LLCs confined in small nanoparticles dispersed in water. They focus on monoglyceride-based systems and also touch on potential applications of these formulations in the area of food colloids and dispersions.

Kulkarni and Glatter, in Chapter 6, review the hierarchical organization of lyotropic liquid crystals from the lipid length scale up to the macroscopic organization of emulsified liquid crystalline systems, with special emphasis on their end-use applications in dispersed systems in the form of oil-in-water emulsions, high internal phase emulsions, and gels.

Chapter 7, by Amar-Yuli, Aserin, and Garti, is a review of the current strategies available for the use of LLCs as templates for the synthesis and alignment of nanostructured materials. The chapter reviews carefully the templating effects in both inorganic and organic materials throughout the main classes of available lyotropic mesophases.

Libster, Aserin, and Garti, in Chapter 8, open the discussion on the use of LLCs as drug delivery vehicles. The different intrinsic diffusion of guest molecules as a function of the mesophase structure are discussed in details, and different means available to tune this diffusion are discussed, considering both external stimuli and “doping” strategies, such as the use of membrane piercing agents.
Chapter 9, by Boyd and Fong, is a discussion of the different types of external stimuli to induce a release of drugs on demand. Recent developments in the field are carefully reviewed and external stimuli such as temperature, pH, and light are discussed in details.

Chang and Nylander (Chapter 10) discuss the problem of dealing with nonlamellar lyotropic liquid crystalline nanoparticles, mostly hexasomes and cubosomes, at interfaces and surfaces. The chapter provides a state of the art on the techniques available to detect the adsorption and structures of these nanoparticles at interfaces, their formation, and implications for biological interfaces and drug delivery.

Chapter 11, by Géral and colleagues, concludes the book by providing a practical direct example of the relevance of lyotropic liquid crystalline nanoparticles, by discussing their use as nanocarriers for targeting of cells expressing brain receptors. The chapter screens self-assembled lipid systems suitable for the encapsulation of neurotrophic peptides and demonstrate their potential in targeting neuronal therapeutic applications.

To summarize, the present book gathers an impressive set of contributions by leading scientists in the area, overarching the entire framework in which lyotropic liquid crystals are today investigated worldwide; this is done by moving from a very fundamental perspective into the possible practical applications area of these materials. Such a contribution was missing from available literature, and it is in the scope of this book to timely fill this gap. It is to be hoped that this outstanding set of reports will not only serve scientists working in the field but will also become an inspiring source for younger scientist generations and also serve students in their education process in the area of nanosctructured self-associating soft materials.

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