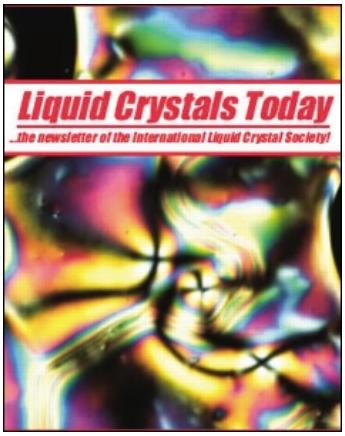

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BOOK REVIEW

Molecular Dynamics of Liquid Crystals

Editors: G. R. Luckhurst and C. A. Veracini

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Although the Advanced Study Institute which gave rise to this volume was held more than 5 years ago, its proceedings were published in 1994, and it has taken a further 2 years for this review to be completed. As with fine wines, aging can improve the product, and in this case the effort over a period of time which has gone into the preparation of the final volume can be more than justified by the quality of the result. The book constitutes a massive information source on all aspects of the molecular dynamics of liquid crystals, but it excludes the macroscopic dynamical phenomena described in terms of viscoelastic responses. There are 23 contributed chapters totalling nearly 600 pages, and these have been written by the experts in the field. The NATO ASI was organised to consider the effects of long range orientational and positional order in liquid crystals on their dynamics, and the lectures given at the Advanced Study Institute were developed into the chapters of this volume, which now represents more of a textbook than a research text. The chapters are ordered so that the theoretical background to liquid crystalline order and dynamics comes first, followed by descriptions of the techniques and the interpretation of results. The techniques covered are nmr, esr, Raman and ir spectoscopy, dielectric relaxation, neutron scattering and fluorescence depolarisation. For all these techniques, applications are considered, but at the end of the book a handful of chapters describes specific applications to polymers, lyotropic liquid crystals and lipids.

The introductory chapter by Hoatson and Levine sets the scene, and rightly draws attention to the confusion in interpretation from different techniques due to the fact that they investigate different time windows of the complex motion in liquid crystals. It is difficult to separate the different dynamic processes, and it is generally assumed that translation and rotational motions are independent. Furthermore it is assumed that collisions randomise both linear and angular momentum. There is a further complication in separating internal rotational motion of flexible mesogens from molecular rotation, and the latter from macroscopic fluctuations in director order – indeed this problem is addressed in a number of the following chapters. A useful comparison of the various techniques used to study lc dynamics is given which specifically notes the different time scales probed by the techniques.

Chapters by Zannoni and Ferrarini, Nordio and Moro deal respectively with orientational ordering in liquid crystals (not a dynamic description) and rotational diffusion models for nematic and smectic phases. The statistical mechanics of orientational and translational dynamics is further developed by Freed, Nayeem and Rananavere as a basis for the interpretation of esr experiments. Computer simulation has an important role in the study of dynamics, in particular in testing particular theoretical models, and there are two chapters on M D simulations, one by Pastor on the simulation of Langevin dynamics with applications to lipid bilayers systems – this chapter includes a FORTRAN code for a suitable program. A further chapter by Zannoni gives the mathematical background to the M D method, and its application to liquid crystals; he also describes the evaluation of time correlation functions from M D simulations. Four chapters on nuclear spin relaxation deal very thoroughly with the theory and experimental application of this powerful technique for studying liquid crystal dynamics. One chapter from Vold and Vold deals with the background theory, and points out some of the difficulties relating to the use of probes and the contribution of director fluctuations, a topic which is discussed in greater detail in a second chapter from Vold and Vold. Details of experimental techniques in nuclear spin relaxation are given in chapters by Kothe and Stohrer and Noack and Schweikert. The former authors emphasise the complexity of liquid crystal dynamics which are a superposition of local and collective motions, however they point out that by using different relaxtion techniques various motions can be differentiated from 10^{-11}s to slow motions occurring on a time scale of 10 s. Noack and Schweikert deal specifically with the technique of field cycling nmr and describe a number of applications to liquid crystals.

The use of probes is well-established in studying lc dynamics using a number of techniques, but the relationship between the organisation of probe molecules and the host liquid crystal is not always straightforward. This problem is addressed in a chapter by Veracini and Shilstone. Probes are essential in the use of esr to study liquid crystal dynamics, and various aspects of this technique are covered in four consecutive chapters by Freed, Nayeem and Rananavere. These chapters almost constitute a monograph on the esr of liquid crystals, and as well as providing a detailed background to the technique, applications to a wide variety of liquid crystal systems including thermotropics, lyotropics and lipids are given. The analysis of esr spectra and interpretation of results is given in detail, and methods for extracting information in orientational order and phase transitions are also described.

Raman and IR spectroscopy of liquid crystals probes particularly vibrational bands, and line-shape analysis can be

used to give time correlation functions for molecular reorientations; this technique is described in detail by Fontana. A widely used technique to study lcs is dielectric relaxation spectroscopy, and the chapter by Williams gives an overview of the technique and applications to low molecular weight and polymer liquid crystals. Neutron scattering is a complementary technique to all others in the study of molecular dynamics, and it can give information on both translational and rotational diffusion. The chapter by Richardson covers both the background and gives some examples of neutron scattering studies of smectic phases. The final technique to be described in this comprehensive volume is of fluorescence depolarisation by Levine and van Ginkel. As in previous chapters the background to the technique is described, but as pointed out by the authors, the lack of suitable fluorophores has limited applications to liquid crystals. Results are given for probes 1,6 diphenylhexatrene (DPH) and trimethylammonium DPH in a variety of lipid bilayers.

This extensive volume is completed by four chapters on applications of dynamic methods to particular systems. Kothe and Muller describe pulsed dynamic nmr studies of a variety of polyesters having different degrees of conformational flexibility. A brief overview on aggregation of amphiphiles in lyotropic lcs is provided by Veracini and Catalano, though there is not much information given on dynamical aspects. Nmr relaxation studies of bilayer lipids are described by Kothe and Mayer, and results are given on both internal and the collective motion of lipid molecules in membranes. Further studies on lipids and other lyotropic liquid crystals is provided by the final chapter from Lindblom, Johansson, Wikander and Eriksson which gives an overview of both the structure and dynamics of cubic and reversed hexagonal phases as studied by a variety of techniques.

As mentioned in the beginning of this review, this volume provides the most comprehensive source book relating to the study of dynamical processes in liquid crystals and the editors Luckhurst and Veracini are to be congratulated on their perseverance in bringing this project to such a successful conclusion. The volume should be a source book for a number of years to come, and is a most worthy addition to previous publications in the NATO ASI series.