SMECTIC LIQUID CRYSTALS

Textures and Structures

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Smectic Liquid Crystals—Textures and Structures

To our respective wives—Marjorie and Ann—who have too often, with our families, been neglected in the cause of liquid crystals, and to whom therefore this book owes a great deal.

Preface

This book is intended as a practical and useful experimental guide to the textures and classification of smectic liquid crystals of different polymorphic types. The period of writing and construction of the book has coincided with a particularly active era during which knowledge of smectic systems has evolved at a rapid rate. As this has happened, it has been necessary to revise the original text, introduce new sections, and extend the examples of textures given by the photomicrographs. This activity has consumed time, but we hope that the result is a superior text with better coverage of the subject. Even so, it became clear that some areas of development still needed discussion, but that this would be difficult to integrate into the existing text. An appendix up-dating these topics (Chapter 10) has been included as a practical way of overcoming this difficulty.

As elaborated in the Introduction, this book is intended not simply for those already knowledgeable in the field, but also for the research worker who is beginning work in the complex area of smectics and wishes to use optical microscopy for the purposes of phase identification. This is, of course, a subject in which experience counts for a great deal. The authors hope to pass on to relative newcomers to the field some of their own experience, and to provide them with reference photographs of textures that are *typical* of those that may be encountered in novel materials. In electing to portray typical textures, this book does differ somewhat from another (Demus and Richter, 1978) dealing with liquid crystal textures, in which considerable emphasis is placed on the effects of structural disclinations upon texture and the origins of these in local deformations of or discontinuities in the arrangement of the molecules. This aspect is important, but we judged that the average research worker is first concerned with what is typical. The detailed effects of deformations on texture may be considered with benefit later, and in this respect, the two books are complementary.

This book was conceived several years ago when the two authors worked in collaboration at the University of Hull. It has progressed over the years, during which one of us (JWG) moved to the United States.

In compiling this book, we have been helped in many ways, and wish to express particular gratitude to Mrs R. Knight for typing the text, Mr A.T. Rendell for his valued work in producing the colour-true photographic prints of textures, Professor A.J. Leadbetter of the Rutherford Appleton Laboratories for many helpful discussions, Professor H. Sackmann, Professor D. Demus, and their colleagues of the University of Halle, East Germany for their co-operation in reaching, with us, an agreed system of nomenclature for some of the smectic modifications, and the Department of Chemistry of the University of Hull, England, for making available facilities without which this book could not have been completed.

G.W.G.
J.W.G.

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Demus, D. and Richter, L. (1978). *The Textures of Liquid Crystals.* V.E.B. Deutscher Verlag für Grundstoffindustrie, Leipzig.

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S_{VII} (TBBA)	Plate 58
S_2 (CCH3)	Plate 59
S_3 (CCH3)	Plate 60

Introduction

In recent years, experimental and theoretical studies of smectic liquid crystals have grown steadily in complexity as a widening range of polymorphic modifications of the smectic state has gradually been brought to light.

Even to the expert in the field, the situation concerning these many polymorphic modifications, their structure, and their nomenclature can be quite confusing. This arises partly because, with regard to structure, we are still in a position of developing knowledge and understanding, and partly because the history of the unfolding of the subject (and some misconceptions in the past) led, at one stage, to the use of a duality of nomenclature by different groups of workers in the field. To a comparative newcomer to the area, the literature on smectic polymorphism can be quite bewildering therefore; literature reports of the smectic properties of a given compound can employ not only different code letters to describe the same polymorphic smectic states, but also an even more confusing, inverted usage of pairs of code letters.

The positive identification of the polymorphic class to which a particular smectic modification belongs must nowadays rest on information gleaned from several experimental sources, including X-ray diffraction, but microscopic studies of the textures of the different smectic forms still remain, and will remain a powerful and economically practical experimental means of classifying smectic phases, particularly when these studies are combined with miscibility investigations.

The primary aim of this book has therefore been to present to the reader a collection of coloured photomicrographs of the textures of established examples of the different smectic polymorphic modifications. In choosing these photomicrographs, care has been taken to ensure that the textures are representative of the phase in question. That is, we have not yielded to the temptation to photograph abnormal regions of the texture arising from unusual deformations of the smectic structure caused by surface effects. In the belief that this book will be of service to the comparative beginner who is attempting to gain experience and knowledge in the field

of the microscopy of smectics, as well as to those more expert in the subject, we have therefore been concerned to depict textures which are typical of the phase type and therefore likely to provide a good guide to the probable class of any unclassified smectic phases that may be encountered. In the case of the textures presented therefore, no special surface treatments of the glass microscope slides and coverslips have been used. Clean slides and coverslips, lightly wiped with lens tissue have been employed.

To ensure that pretransitional effects in the phases do not interfere, photomicrographs of textures have in all cases been taken with the temperature of the sample maintained well within the limits of the temperature range over which the smectic modification in question is thermodynamically stable. However, changes in texture that occur at a phase transition are frequently an important factor in phase identification; it was therefore judged useful to include some sequences of photomicrographs for specific compounds to illustrate the textural changes occurring as one phase type develops from another with change in temperature.

The text (Chapters 1 to 10) which accompanies the section on microscopic textures has been aimed at supplying to the reader a review of the sequence of development of knowledge relating to each of the smectic types. This has created one problem, since our understanding of smectic structure and indeed current views on whether particular modifications should be regarded as smectic liquid crystals or as crystal-type smectics (or even crystals) have been evolving during the writing process. We decided therefore that the text should carry an appendix (Chapter 10) in which parts of the text written earlier are updated in the light of current knowledge. To help to direct the reader's attention to the areas covered by Chapter 10, they are summarized below:

Hexatic and crystal smectic phases—with particular reference to B phases;
Antiphase behaviour and the role of bilayers in smectic A, B, and C phases;
Ferroelectric phases—chiral smectic C and other chiral tilted phases;
Structural features of smectic phases—a summarizing figure (page 153) and tables designed to function as *aides mémoires*.

It is hoped in particular that these chapters will provide an insight into the complex and often confusing literature on smectic liquid crystals. As mentioned already, aspects of nomenclature have been particularly problematical, and if these chapters remove some of the barriers which have in the past made if difficult for the increasing number of new workers involved in studies of smectic systems to divine and obtain a coherent view of smectic polymorphism, then they will have served a useful purpose. Since the text has been written for practically oriented readers whose backgrounds may be very varied (chemistry, physics, engineering, electronics, biology) because of the multidisciplinary involvements of liquid