

Preface

The aim of this book is to survey phenomena in soft matter systems that are triggered by electric fields. Strong electric fields are easily generated and cause stronger interactions in most materials compared to magnetic fields or to gravity. In confinement, electric fields exceeding 10 MV/m are readily produced by low-voltage sources. The manipulation of liquid and soft materials by electric fields is therefore well suited for nanotechnological and microfluidic applications.

The topics covered in this book include field-induced phase transitions in simple liquids and polymers, liquid interfacial instabilities, electrowetting, and orientational and order-order phase transitions in block-copolymers. The level of text is adequate for graduate students and researchers alike. The rich static and dynamical behavior described in the chapters are explained invoking simple physical mechanisms and physical quantities, such as the dielectric properties and conductivity of the liquids or polymers.

The chapters are organized as follows. The first chapter, by D. Andelman and R. Rosensweig, is an introductory review of modulated phases. It surveys several examples of self-organizing materials, such as magnetic garnet films, two-dimensional ferromagnetic layers, and Langmuir dipolar films. It also describes in detail the well-known instabilities of ferrofluids subjected to magnetic fields (e.g. the Rosensweig instability).

The second chapter by A. Onuki deals with solvation effects in polar fluids. By using a Ginzburg-Landau theory, he shows how to calculate the equilibrium ion and electric field distributions near an interface. The surface tension between two phases and the structure factor in the one-phase region near a critical point are given. The following chapter, by K. Orzechowski, is closely related. It gives a concise account of the changes occurring in the phase diagram of mixtures in uniform electric fields. The comparison with the theories of Landau and Lifshitz and the more recent theory by Onuki is also given.

Chapters 4 and 5 describe the behavior of two immiscible liquids in electric fields. T. Russell and J. Bae describe the electrohydrodynamic interfacial instability which develops when a liquid film is subjected to a normal electric field. Here the instability occurs because the electrostatic energy is at a maximum when the external field is perpendicular to a dielectric interface. A fastest-growing wavelength is obtained by a linear stability analysis of pure dielectric liquids. According to the “leaky dielectric” model of G. I. Taylor, the existence of residual conductivity leads to the appearance of large viscous stresses, which lead to a faster dynamics and smaller values of the dominant wavelength. Related phenomena are discussed by F. Mugele in his review of electrowetting. Dissolved ions help to decrease the contact angle of a droplet placed on a solid substrate. The chapter presents the theory and experiments of contact angle saturation, the dynamics of droplets in microfluidics channels, droplet breakup, and various interfacial instabilities.

Q. Tran-Cong-Miyata and H. Nakanishi’s chapter deals with phase separation transitions in polymer systems driven by light. They show that chemical reactions can be used to select the fastest-growing mode in the phase-separation process of polymer mixtures. Hierarchical structures, morphologies with multiple length-scales, and spatio-temporal control of the system can also be obtained.

Chapter 7, written by M. Schick, presents a fundamental approach to the thermodynamics of purely dielectric self-assembled phases in electric fields. This chapter first explains in detail how the electrostatic energy of such systems should be calculated. As examples, it discusses order-order, order-disorder, and orientational phase transitions which occur in block-copolymers.

A. Boeker and K. Schmidt describe the influence of electric fields on block-copolymers in solutions. Their unique experimental method allows them to record the dynamical orientation process, which is found to depend on the distance to the critical point. In addition, they describe an intriguing phenomenon, the reversible change in spacing of a lamellae-forming system induced by an electric field. The last chapter, by A. Zvelindosky and G. Sevink gives an account of the forefront of numerical methods used to calculate orientation and phases of block-copolymers in external fields. They show that dynamical density functional approaches can be used to obtain the dynamics of phase ordering as well as the long-time steady-state.

We believe this book will be useful to people entering the field (no pun intended) as well as to active researchers. We hope the book will

stimulate further innovation in this lively and fruitful interdisciplinary domain.

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