

Effective medium theory of light scattering in polymer dispersed liquid crystal films

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Abstract. We present calculations of the optical properties of PDLC films subjected to normally incident unpolarized light, in the long-wavelength régime under which the Rayleigh–Gans approximation applies. The calculations use an effective medium theory to take account of dependent scattering effects due to close packing of droplets, and use the Percus–Yevick approximation for hard spheres to account for interference effects. The director configurations inside the droplets are found using the effective medium theory which we have developed in earlier papers. Typical results are presented for radial and bipolar droplets. Detailed quantitative results have been derived for the optical characteristics in the presence of an applied field for the technologically important case of PDLC films containing partially ordered bipolar droplets.

1. Introduction

This paper is the third in a series of detailed theoretical studies of the properties of polymer dispersed liquid crystal (PDLC) films. These materials combine some useful properties of ceramic and liquid crystalline materials. There are several current and potential applications, ranging from large-area flexible windows and signs to high-resolution active matrix addressing devices and direct view displays [1–3].

In basic outline, a PDLC film consists of randomly distributed micrometre-size liquid crystal droplets embedded in an isotropic polymer matrix. PDLC films have rather dramatic light scattering properties. They can be switched from an opaque to a clear state by application of an external electrical field. A successful explanation of their properties involves: (i) a description of the electrostatics and director reorientation within the droplets and (ii) an understanding of the consequence of that reorientation on the light scattering properties not only of the individual droplets but also of the collection of droplets taken as a whole.

In two previous papers [4, 5] (referred to as I and II in this paper) we have addressed problem (i) of the previous paragraph. In this paper we finally turn our attention to the technologically important question of light scattering by droplets in the polymer matrix.

Let us first briefly review what is known about the mode of operation of PDLC films, leaving aside quantitative details. A typical PDLC geometry is shown in figure 1. Individual droplets are filled with inhomogeneous nematic liquid crystal. There is a dielectric mismatch between each of them and the surrounding polymer matrix. Each droplet therefore scatters light incident upon it. In the presence of a field, the nematic directors inside the droplets align and it can be arranged that the relevant dielectric properties of droplets match those of the polymer matrix. The light scattering reduces or (if we are lucky) disappears and the PDLC film becomes clear. What remains is detail. Unfortunately it is this detail which controls the efficiency of the device and it is on this detail that we shall concentrate in this paper.

This paper is organized as follows. In section 2 we give a brief theoretical overview of the whole area. Next in section 3 we review in more detail previous theoretical work on light scattering in PDLC systems. In section 4 we explain the innovations which we make in this paper which improve understanding of light scattering in PDLC films. In section 5 we show how our theory can be used to perform explicit calculations for some simple cases and present some numerical results. Then in section 6 we discuss the optical properties of a PDLC film as a field is progressively imposed upon it. Finally in section 7 we make some concluding remarks. Some technical results on droplet correlations drawn from elsewhere are relegated to an appendix. Further quantitative detail, in particular a

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Mike Jess



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Technology at a Glance ,1995 Polarized Light and Optical Systems Russell A. Chipman,Wai Sze Tiffany Lam,Garam Young,2018-07-16 Polarized Light and Optical Systems presents polarization optics for undergraduate and graduate students in a way which makes classroom teaching relevant to current issues in optical engineering This curriculum has been developed and refined for a decade and a half at the University of Arizona s College of Optical Sciences Polarized Light and Optical Systems provides a reference for the optical engineer and optical designer in issues related to building polarimeters designing displays and polarization critical optical systems The central theme of Polarized Light and Optical Systems is a unifying treatment of polarization elements as optical elements and optical elements as polarization elements Key Features Comprehensive presentation of Jones calculus and Mueller calculus with tables and derivations of the Jones and Mueller matrices for polarization elements and polarization effects Classroom appropriate presentations of polarization of birefringent materials thin films stress birefringence crystal polarizers liquid crystals and gratings Discussion of the many forms of polarimeters their trade offs data reduction methods and polarization artifacts Exposition of the polarization ray tracing calculus to integrate polarization with ray tracing Explanation of the sources of polarization aberrations in optical systems and the functional forms of these polarization aberrations Problem sets to build students problem solving capabilities

Materials Science and Engineering Laboratory ,1993 **An Assessment of the National Institute of Standards and Technology Center for Neutron Research** National Research Council,Division on Engineering and Physical Sciences,Laboratory Assessments Board,Panel on Neutron Research,2008-11-27 The National Institute of Standards and Technology NIST Center for Neutron Research NCNR is a national user facility whose mission is to ensure the availability of neutron measurement capabilities in order to meet the needs of U S researchers from industry academia and government agencies A panel of experts from the National Research Council evaluated the NCNR by the following criteria 1 the technical merit of the current laboratory programs relative to the current state of the art worldwide 2 the adequacy of the laboratory facilities equipment and human resources as they affect the quality of the laboratory technical programs and 3 the degree to which the laboratory programs in measurement science and standards achieve their stated objectives and desired impact This book finds that NCNR is an extremely reliable and comprehensive neutron scattering facility Even as the other neutron source in the nation the Spallation Neutron Source SNS becomes increasingly operational and the Oak Ridge High Flux Isotope Reactor HFIR comes back online the NCNR will continue to be a vital resource for meeting the broad spectrum of user needs for and scientific objectives related to neutron scattering *Small-Angle Scattering* Ian W. Hamley,2021-04-19 SMALL ANGLE SCATTERING A comprehensive and timely volume covering contemporary research practical techniques and

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Nachhaltige Erzeugung von neuartigen mikro- und nanoporösen Materialien mit nahekritischem CO₂ Roland Oberhoffer, 2015-07-14 In Anbetracht der Energiewende können neuartige nanozelluläre Polymerschäume aufgrund ihrer extrem geringen Wärmeleitfähigkeit einen großen Beitrag zur Energieeinsparung leisten Um diese Schäume nachhaltig herzustellen und den ökologischen und ökonomischen Nutzen zu maximieren sollte nahekritisches CO₂ als Treibmittel verwendet werden da dieses umweltfreundlich und günstig ist In diesem Zusammenhang stellt das Principle of Supercritical Microemulsion Expansion POSME ein vielversprechendes Verfahren dar wobei eine Mikroemulsion aus mit überkritischem Treibmittel gefüllten Mizellen expandiert und die externe Phase fixiert wird Als Modellsysteme wurden zunächst zuckerhaltige Propanmikroemulsionen untersucht deren Schäume allerdings nur Porengrößen im unteren Mikrometerbereich aufwiesen Untersuchungen des Phasenverhaltens und der Mikrostruktur mittels Kleinwinkelneutronenstreuung SANS zeigten dass eine bikontinuierliche L3 Struktur vorliegt Periodische Drucksprünge in Kombination mit zeitaufgelösten SANS Messungen lassen erkennen dass die Nanostruktur schon durch einen bei Beginn der Expansion einsetzenden Entmischungsvorgang verloren geht Die erhaltenen mikroporösen Zuckerschäume stellen allerdings ein interessantes low calorie Produkt für die Lebensmittelindustrie dar Durch den systematischen Austausch der nichtessbaren Tenside durch essbare Saccharosestearinurester und die Verwendung von nahekritischem CO₂ an Stelle des Propan konnten in einem Laborextruder essbare Zuckerschäume produziert werden Um dem gesetzten Ziel der großtechnischen Produktion polymerer Nanoschäume dennoch näher zu kommen wurde ein weiteres alternatives Verfahren das Nano Foam by Gel Acetone Foam Formation via Expansion Locking NF GAFFEL entwickelt in dem ein Polymer z B Polystyrol mit einem Lösungsmittel z B Aceton zu einem bikontinuierlichen Gel gequollen wird Wenn dieses Gel in eine CO₂ Atmosphäre unter hohem Druck gebracht wird kommt es zu einer Vermischung von Lösungsmittel und CO₂ so dass mittels Expansion eine Extraktion des Lösungsmittels erfolgt und ein nanoporöses Material resultiert wobei das Lösungsmittel durch Kondensation recycled wird Die so hergestellten offenporigen Polymerschäume weisen Porendurchmesser zwischen 100-200 Nanometer und Dichten im Bereich von 0,10-0,40 g/cm³ auf

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Annual Meeting American Crystallographic Association. Meeting, 1995

Introduction to Physical Polymer Science Leslie H. Sperling, 2005-11-25

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Publications United States. National Bureau of Standards, 1989

Characterization and Analysis of Polymers Wiley, 2008-02-08

Based on Wiley's renowned *Encyclopedia of Polymer Science and Technology* this book provides coverage of key methods of characterization of the physical and chemical properties of polymers including atomic force microscopy chromatographic methods laser light scattering nuclear magnetic resonance and thermal analysis among others

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