Journal of Magnetism and Magnetic Materials 452 (2018) 343–348

Contents lists available at ScienceDirect

Journal of Magnetism and Magnetic Materials

journal homepage: www.elsevier.com/locate/jmmm

Research articles

New grafted ferrite particles/liquid crystal composite under magnetic field

D. Manaila Maximean

Physics Department, University "Politehnica Bucuresti", Spl. Independentei 313, R-060042 Bucharest, Romania

ARTICLE INFO

Article history:
Received 23 July 2017
Received in revised form 20 November 2017
Accepted 28 December 2017
Available online 29 December 2017

Keywords:
Liquid crystals
Magnetic nanomaterials
Ferronematics
Colloidal particles
Nanocomposites
Freedericksz transition

ABSTRACT

A new colloidal composite formed by specially synthesized dimethylphenyl ferrite particles and a nematic liquid crystal (LC) is presented. By applying a small magnetic field during polarizing optical microscopy observations, it was found that the magnetic moment of the synthesized ferrite is perpendicular to the director of the LC. The optical transmission of laser light across the ferronematic was investigated under magnetic field. The critical magnetic field corresponding to the Freedericksz transition was obtained and discussed according to the Burylov and Raikher theory.

© 2017 Elsevier B.V. All rights reserved.

1. Introduction

Many organic substances do not present a unique transition between solid and liquid, but a serial of transitions, passing through states with intermediate properties between crystal and liquid [1,2]. Liquid crystals (LCs) are characterized by the presence of orientational order and the total or partial absence of positional order [1–3].

Application of LC as displays have boosted the scientific interest [3–5] and, in the last decade, new LCs [6–8] and nanoparticles dispersions in LCs [9–13] are designed for application in organic electronics, as e.g. organic light-emitting diode, thin film transistors, light valves, solar cells.

When used in conjunction with magnetite particles, new composite materials known as ferronematics (FN) are obtained [14–16]. In this paper, a new highly ordered FN formed by using a specially synthesized ferrite particle with phenyl terminal groups, compatible with the LC, is presented. The mixtures exhibited long term stability (month-order). Sandwich type samples using glass plates with homeotropic and planar alignment to the substrate were manufactured.

The samples were placed in magnetic field, under crossed polarizers, and investigated by measuring the optical transmission of the laser light. When slowly increasing the magnetic field, at the critical value B_c, the LC's molecular director exhibits a change in orientation, leading to a variation of the refractive index. This, in turn, leads to a change in the intensity of the emerging laser beam, indicating the start of the Freedericksz transition. Under static magnetic field conditions, the Freedericksz transition was obtained and the critical magnetic fields determined.

2. Experimental

2.1. Particle synthesis

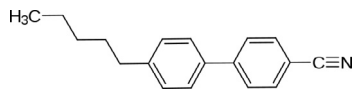
To obtain magnetic particles with a good compatibility with a liquid crystal having phenyl terminal groups, K15 (Merck) in this case, the phenyl group was chemically included in the magnetite particle, during its synthesis. The obtained particles are of the "hairy" type, with the phenyl ending groups towards the LC. Starting from Fe_3O_4 and CH_2Cl_2 a dispersion was formed by mechanic agitation at 350 rot/min, in controlled nitrogen atmosphere [17]. The dispersion was stirred for 30 min, ultrasonicated for 5 min and then the precursor dimethylphenyl ethoxysilane compatibilizer agent was added and the mixture was stirred for another 3 h. The final compound was washed with CH_2Cl_2 and dried. The mole fraction of the reactant (surfactant) at 100 g was determined by TGA and was 0.0408 for dimethylphenyl ethoxysilane (PhMe2ES). The final compound particles are dimethylphenyl ferrite, $Fe_3O_4(CH_3)_2C_6H_5$, particle code: DFF, and have a diameter of 168 nm determined by DLS.

E-mail address: doina.manaila@physics.pub.ro

https://doi.org/10.1016/j.jmmm.2017.12.096
0304-8853/© 2017 Elsevier B.V. All rights reserved.

2.2. Sample preparation

The obtained particles were mixed with the K15 thermotropic LC, from Merck, as presented in Table 1. Liquid crystal K15 (or 5CB) is 4-cyano-4′pentylbiphenyl, chemical formula $C_{18}H_{19}N$:



The transition temperatures are:

$$Cr \xrightarrow{296.9\ K} N \xrightarrow{308.4\ K} I$$

where *Cr* stands for crystalline state, *N* – nematic and *I* – isotropic and has a positive dielectric anisotropy $\Delta\varepsilon > 0$. Being a thermotropic LC, its magnetic anisotropy, χ_a is positive; thus, when subjected to a strong enough magnetic field, the LC molecules will reorient in the direction of the magnetic field [3].

Sandwich type glass cell, consisting of two glass plates separated by spacers have been prepared. For homeotropic-aligned cells DMOAP, Dimethyloctadecyl [3-(trimethoxysilyl) propyl] ammonium chloride was used, in the following ratios: 899 parts isopropanol, 100 parts distilled water, 1 part DMOAP. The solution was deposited onto glass plates by spin coating and polymerized for 15 min at 100 °C. For planar alignment, the glass plates were treated with a 0.1% concentration polyvinyl alcohol, deposited by spin coating and polymerized at 120 °C for one hour, slowly cooled down to room temperature, and rubbed with a smooth cloth in the direction of alignment. The cell thickness was of about 150 μm.

The nominal parameters of the samples are presented in Table 1. The LC and the LC-DFF composite have been filled in the cells and sealed.

2.3. Experimental apparatus

The experimental setup used to study the influence of magnetic field on the FN is schematically presented in Fig. 1 and discussed in detail in [18].

Table 1
Characteristics of LC and FN samples.

No	Sample code	Composition	Alignment of glass plates	Concentration % by mass
1	H0(K15)	Liquid crystal K15	homeotropic	–
2	H1/(K15/DFF)	K15/dimethylphenyl ferrite particles	homeotropic	0.05
3	H2/(K15/DFF)	K15/dimethylphenyl ferrite particles	homeotropic	0.1
4	H3/(K15/DFF)	K15/dimethylphenyl ferrite particles	homeotropic	0.2
5	P0(K15)	Liquid crystal K15	planar	–
6	P1/(K15/DFF)	K15/dimethylphenyl ferrite particles	planar	0.05
7	P2/(K15/DFF)	K15/dimethylphenyl ferrite particles	planar	0.1
8	P3/(K15/DFF)	K15/dimethylphenyl ferrite particles	planar	0.2

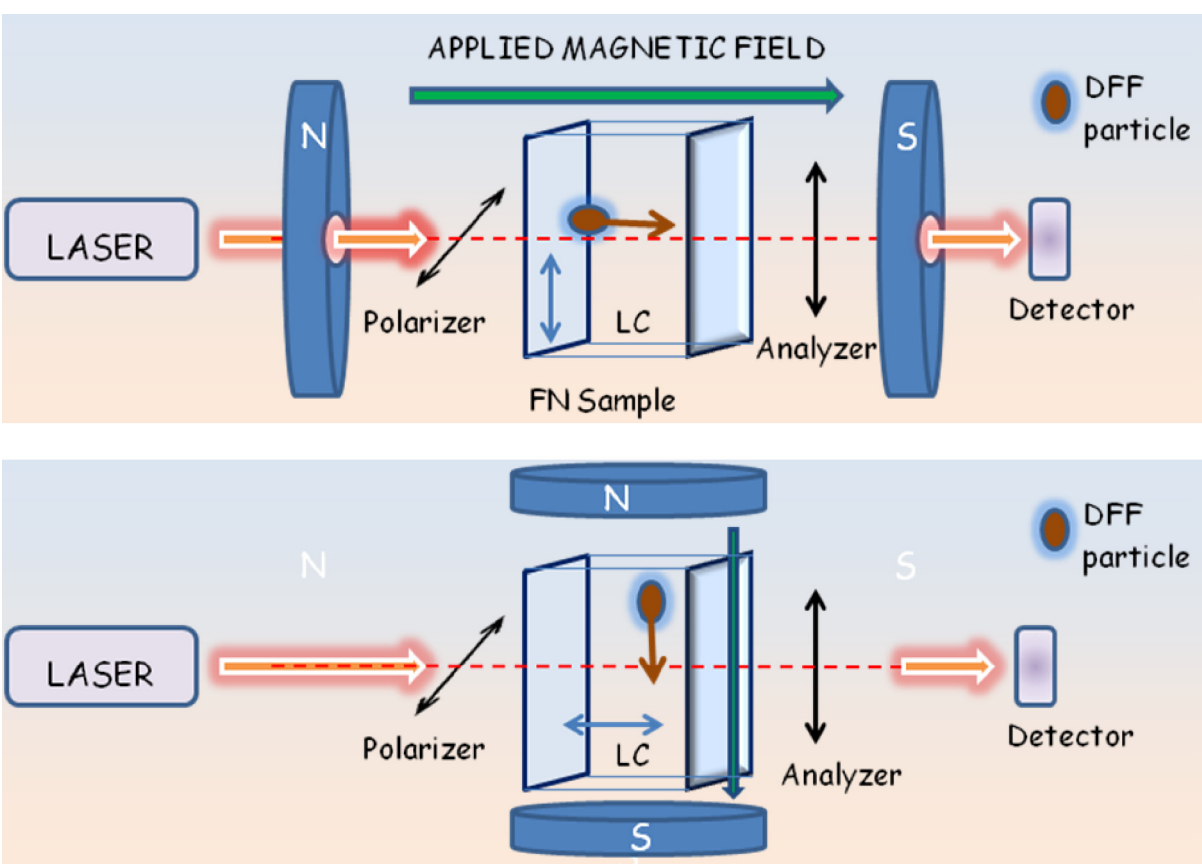


Fig. 1. Experimental set-up for: (up) planar aligned FN; (down) homeotropic alignment. The direction of initial alignment of LC is marked by double arrow.

Download English Version:

https://daneshyari.com/en/article/8153915

Download Persian Version:

https://daneshyari.com/article/8153915

Daneshyari.com