












Chirality transfer to harness mesophase transitions in liquid crystal mixtures containing an oxadiazole derivative

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ABSTRACT

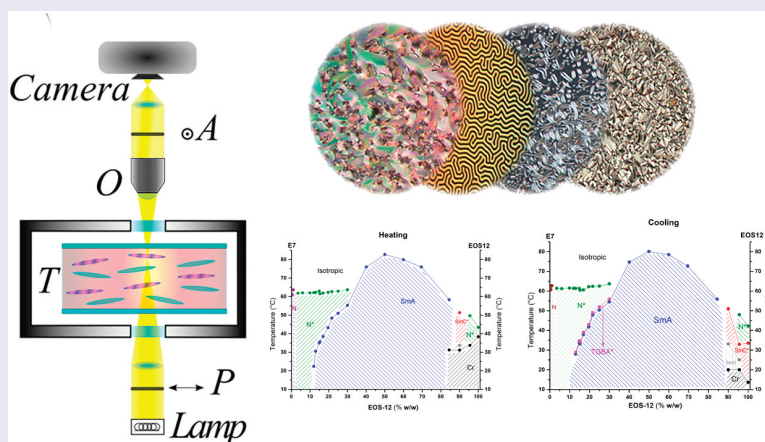
Chiral liquid crystal mixtures are an important field of research in the development of these materials. The main advantage of chiral liquid crystal mixtures is their ability to produce an optically active three-dimensional structure. Moreover, 1,3,4-oxadiazoles have been widely used as electron-transporting/hole-blocking materials or emitting layers in electroluminescent diodes and nonlinear optical materials owing to their interesting properties. Here, we investigate the phase transitions in a mixture of a chiral oxadiazole derivative liquid crystal, EOS-12, and a traditional nematic liquid crystal, E7. EOS-12 is miscible with the E7 matrix at all concentrations. The mesomorphic properties of these mixtures were studied using differential scanning calorimetry (DSC), polarised optical microscopy (POM) and digital colourimetry analysis. In addition, the cholesteric pitch is measured using the Grandjean-Cano technique and photophysical studies were performed in solutions and films. Mixtures show polymorphism depending on the concentration and temperature: nematic, chiral nematic, TGBA*, and smectic phases. A temperature-concentration phase diagram was established using POM. Stabilisation of the SmA phase is observed with a greater temperature range than the constituents of the mixture. According to these results, the properties of the mixture can be used to create various material functionalities, depending on the composition of the mixture.

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Introduction

Liquid crystals form the basis of many functional and structural materials and devices. In most technological applications, Liquid crystalline materials are not pure. The mixing of different liquid crystals is a common technique for tailoring their properties for specific

applications [1]. The main advantages of liquid crystal mixtures are their remarkable optical and electrical properties, such as low optical losses and wide viewing angles. They also provide excellent temperature stability and colour uniformity, making them ideal for application in any environment. A liquid crystal mixture is

a combination of two or more compounds that can be either homogenous or heterogeneous depending on the compounds used [2]. The physical properties of liquid crystal mixtures are a function of their composition, and small changes can have pronounced effects on observables such as dielectric constants [3], linear and nonlinear optical properties [4–6], and response times [7]. Common components of mixtures include chiral dopants, surfactants, and thermotropic liquid crystals.

Chiral liquid crystal mixtures are an important field of research in the development of these materials [8]. The main advantage of chiral liquid crystal mixtures is their ability to produce an optically active three-dimensional structure. This structure is the result of a combination of liquid crystal molecules, in which the twist and bend deformations are localised, giving rise to some unique optical characteristics. These include birefringence, circular dichroism, and circular polarisability [9–12]. These mixtures have been used to create optically active displays and materials that improve the performance of liquid crystal displays (LCDs) [13]. They have also been used in cholesteric liquid-crystal (CLC) lasers [14], which can be used to create a wide range of optical effects. The anisotropic properties of chiral liquid crystals also make them effective in the production of photonic materials, which can be used to manipulate light at the nanoscale [15,16].

On the other hand, aromatic-substituted 1,3,4-oxadiazoles have been widely used as electron-transporting/hole-blocking materials or emitting layers in electroluminescent diodes and nonlinear optical materials, because of their electron-deficient nature, high photoluminescence

quantum yield, and excellent thermal and chemical stabilities [17]. The 1,3,4-oxadiazole unit can also be used to synthesise different fluorescent chemosensors for transition-metal ions [18,19], biologically active agents [20], and scintillators [21]. The 1,3,4-oxadiazole unit has been widely used to devise a large number of liquid crystals with various mesophases, including uniaxial nematic, smectic, columnar phases, TGBC*, banana phases, and even elusive nematic phases with biaxiality [22]. However, many scientific issues in this field still need to be explored, for instance using these types of compounds in mixtures. Currently, there are no reports on mixtures of chiral oxadiazole derivatives. In this context, the goal of this research is to investigate the novel properties of a liquid crystal commercial mixture with this versatile synthon. This new mixture is based on a commercial nematic liquid crystal (E7) and a heterocyclic chiral molecule synthesised in our laboratory. This molecule corresponds to (4-(5-dodecylthio-1,3,4-oxadiazole-2-yl)phenyl 4'-(1''-methyl heptyl-oxy)benzoate) [23]; for simplicity, we denote this molecule as EOS-12. The commercial multi-component nematic mixture E7 is an easily accessible reagent that has been widely used in several applications [24]. Both ingredients are liquid crystals within a finite temperature range. Figure 1 shows a representation of the molecules that compose E7 and EOS-12. EOS-12 is miscible at all concentrations in the E7 matrix. Depending on the concentration, the new mixture shows polymorphism, including a chiral frustrated mesophase, such as twist grain boundary A (TGBA*). Unexpectedly, this mixture enhanced the mesomorphic range. Consequently, this

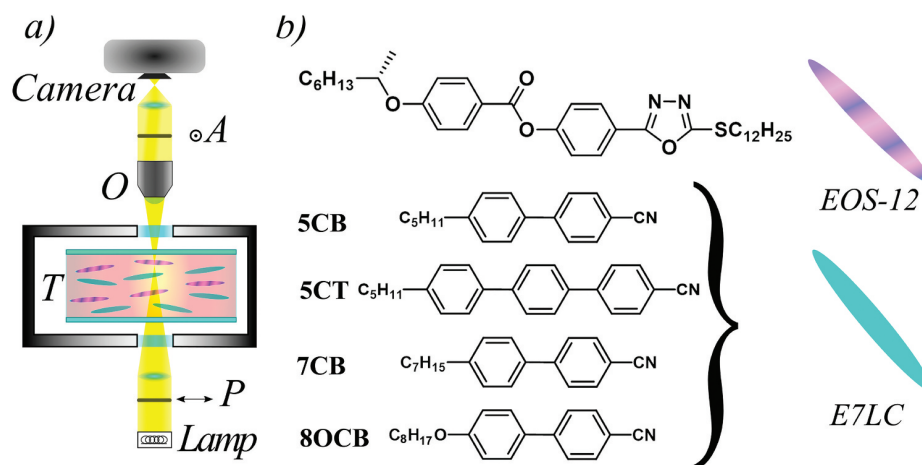


Figure 1. (Colour online) Chiral nematic liquid crystal mixtures. (a) Schematic representation of experimental setup. Where T denotes the thermal control chamber. A white light lamp was used to generate illumination. The microscope is composed of an objective O with a magnification ranging from 5x to 20x. Linear polarisers are represented as polariser (P) and analyser (A). The monitoring and images were captured using a digital camera for texture recording and transition detection, respectively. (b) Schematic structures of EOS-12 molecule and E7 mixture which is composed of 5CB (51%), 5CT (8%), 7CB (25%), and 8OCB (16%). Coloured bars indicate the symbolic representation of the molecules.

mixture acquires new properties and functionality. The characterisation of this new mixture was conducted using polarised optical microscopy and differential scanning calorimetry. In addition, the characterisation of the SmA-N* transition was complemented by digital colourimetry analysis. This technique involves measuring the colour of a sample using a digital imaging system and analysing the data to determine the hue, saturation, brightness, and other characteristics of the sample. Our group has identified that the transformation from RGB to HLS allows us to observe small changes associated with different colours in liquid crystal cells [25]. In this paper, we consider only the lightness parameter reporting the performance of the transition from the smectic phase to the nematic phase as a function of temperature. In addition, the helical pitch of the chiral nematic mesophase was characterised using the Grandjean-Cano method. The ultraviolet – visible absorption and emission properties of the mixtures have been investigated. Photophysical studies were performed on the solutions and films. Combining the above techniques allows qualitative and quantitative information collection on liquid crystal phases and their transitions.

Experimental section

The experimental setup and molecular information of mixtures and some typical textures are sketched in Figure 1. A schematic representation of the polarised optical microscope with a thermal control chamber and a digital monitoring camera is shown in Figure 1(a). The images obtained were processed with appropriate software for colour analysis. The molecular structures of EOS-12 and E7 are illustrated in Figure 1(b). The miscibility of both components was verified in all concentrations.

Materials and methods

EOS-12

The compound (4-(5-dodecylthio-1,3,4-oxadiazole-2-yl) phenyl 4'-(1"-methylheptyl-oxy) benzoate)) was synthesised and characterised following the procedure developed by our group and published in Parra et al. [23]. EOS-12 has a chiral terminal chain, and the other terminal is substituted by a thioalkyl chain with 12 carbon atoms. The rigid component has a substituted oxadiazole heterocycle and is connected with the chiral part by a phenyl ester group. Figure 1(b) shows the chemical structure of EOS-12. For this compound an enantiotropic chiral nematic (N*) phase was observed in the range of 38.4°C to 43.4°C. Furthermore, on cooling, a monotropic

chiral smectic C (SmC*) phase was also observed between 33.5° to 13.6°C.

E7

The Commercial mixture (INSTECH Inc) was used without further purification. The transition temperature of E7 is $T_g -62.5^\circ\text{C}$ N 59.4°C I. This mixture is composed of 51% 4-pentyl-4'-cyanobiphenyl (5CB) (Cr 24°C N 35.5°C I), 8% 4-pentyl-4'-cyanoterphenyl (5CT) (Cr 130°C N 240°C), 25% 4-heptyl-4'-cyanobiphenyl (7CB) (Cr 30°C N 42.8°C I) and 16% 4-octyloxy-4'-cyanobiphenyl (8OCB) (Cr 54.5°C SmA 67°C N 80°C I). Figure 1(b) shows the chemical structure of E7 components.

Mixtures' preparation

Binary mixtures were prepared by weighing each component and dissolving them separately into dichloromethane. The solutions were combined and homogenised, sonicating for 5 min. The solvent was removed by slow evaporation at room temperature.

Preparation of cells

The planar-nematic cells were prepared by introducing the liquid crystal mixture by capillarity in the cell. These cells had a thickness of $d = 20 \pm 0.2 \mu\text{m}$, electrode area of 100 mm^2 of ITO with a thickness of $0.023 \pm 0.05 \mu\text{m}$, a resistance of 100Ω , and polyimide (KPI300B) with a thickness of $0.06 \mu\text{m}$. The cells had a homogeneous alignment layer with a 1° to 3° pretilt angle from the substrate plane.

Characterisation

Polarised optical microscopy (POM)

The samples were studied between two glasses without surface modification. Transition temperatures and textures of mesophases were determined by POM using an Olympus B×51 optical microscope equipped with an Olympus U-TV0.5×C-3 polariser and a Linkam T95-PE hot stage with a PT100 platinum sensor (0.01°C resolution). The sample was monitored at a rate of $0.5^\circ\text{C}/\text{min}$ during the heating and cooling processes.

Differential scanning calorimetry (DSC)

The samples were analysed in a TA instrument Q20. Samples were encapsulated in aluminium pans and studied at a scanning rate of $10^\circ\text{C}/\text{min}$ during heating and cooling. The instrument was calibrated using an indium standard (156.6°C , 28.44 J/g).

Digital colourimetry analysis

This analysis was conducted using a CMOS camera (Thorlabs-DCC1645). The liquid crystal planar-nematic cell ($d = 20 \pm 0.2 \mu\text{m}$) samples were analysed in a Leica microscope (DM2700P) with a thermal control stage and four electrical connectors (Mod. TST350E). Digital colourimetry analysis permits measuring the change of lightness in liquid crystal cells as a function of the temperature using video cameras. Liquid crystals between polarised plates spread multicolour textures that depend on the molecular orientation [6].

Grandjean-Cano pitch measurement technique

A chiral nematic liquid crystal droplet is deposited over a glass plate, using a microcapillary tube, and covered with a planoconvex cylindrical lens. Both the glass plate and the lens are mechanically rubbed in the same direction to induce planar alignment. The sample is observed with the POM technique. The Grandjean-Cano allows measuring the cholesteric pitch based on the curvature of the cylindrical lens and the distance between discontinuous pitch jumps.

Ultraviolet absorbance measurements

The experiments were performed with a Shimadzu UV-1800 spectrophotometer. Emission spectra in the solution and film were acquired using a fluorometer (Photon Technology International Inc. Quanta Master) with a 1 cm path cuvette and solution at concentrations of $2.0 \times 10^{-5} \text{ mol L}^{-1}$ for UV-Vis and $2.0 \times 10^{-8} \text{ mol L}^{-1}$ for fluorescence in dichloromethane. The emission spectra in the film state were acquired from thin films prepared by heating to an isotropic liquid and cooling to room temperature.

Results and discussion

Mesomorphic properties of the mixtures

A series of E7 and increasing amounts of EOS-12 mixtures were prepared, ranging in concentrations from 0.50 wt% to 95 wt% of both components.

The polarised optical microscopy analysis allows us to characterise the richness of polymorphism exhibited by the mixture under study, as summarised in Table 1. Transition temperatures were measured with the polarised optical microscopy technique (POM). The samples were analysed by heating, starting at room temperature (20°C), and cooling throughout the concentration range. Based on the collected information, the phase diagram presented in Figure 2 was constructed. The error bar was estimated with a value of $\pm 0.1^\circ\text{C}$. The graph did not include the concentration error bar

Table 1. Transition temperatures for all mixtures prepared. These data were registered by POM since room temperature.

% EOS-12		% EOS-12	
(E7)	N 61.3 I I 61.3 N	25	SmA 51 N*62.9 I I 62.5 N*51.9 TGBA 50.4 SmA
0.5	N 60.8 I I 60.7 N	30	SmA 55.3 N*63.7 I I 63.7 N*55.9 TGBA 54.5 SmA
1	N 63.7 I I 62.7 N	40	SmA 76.6 I I 68.8 SmA
3.5	N* 61.8 I I 61.4 N*	50	SmA 82.7 I I 80.1 SmA
6	N* 62 I I 61.2 N*	60	SmA 79.9 I I 78.5 SmA
10	N* 62 I I 61.5 N*	70	SmA 76.0 I I 72.7 SmA
12	SmA 22.4 N* 62.1 I I 61.4 SmA	84	Cr 31.2 SmA 58.3 I I 55.9 SmA
13	SmA 30.5 N* 62.3 I I 61.4 N 28.9 TGBA 28 SmA	90	Cr 31.1 SmX 33.8 SmC* 51.3 I I 51.0 SmC*33.1 SmX 20.0 Cr
15	SmA 35.7 N 61.5 I I 60.5 N*34.9 TGBA 34.1 SmA	95	Cr 33.7 N* 49.7 I I 48 N* 32.9 Sm C* 25.1 SmX 20.0 Cr
20	SmA 38.5 N*61.9 I I 60.6 N*39 TGBA 37.9 SmA	100 EOS-12	Cr 38.4 N* 43.4 I I 42.2 N* 33.5 SmC* 13.6 Cr
22	SmA 48.4 N 62.7 I I 62.4 N*49 TGBA 47.9 SmA		

because it is two orders of magnitude lower than the obtained concentration. The commercial mixture E7 (0 wt%) represents a eutectic LC blend with a single nematic – isotropic phase transition temperature (TNI) appearing at 59.4°C . At room temperature, E7 exhibits a nematic phase. These liquid crystalline properties are extended down to the glass transition temperature at -62.5°C .

Note that nematic liquid crystal E7 was miscible with EOS-12 over the entire concentration range. Figure 2 shows the experimental eutectic phase diagram for the mixture E7/EOS-12. The introduction of the chiral dopant (EOS-12) has a pronounced effect on the mesomorphic behaviour of the E7 mixture. The first and most evident observation is a chirality transference to the E7 matrix, appearing from 2 wt% EOS-12 addition. Furthermore, the notorious stabilisation of a SmA phase, with the clearing temperature being significantly higher (19.9°C) in some mixtures.

The addition of 0.5 and 1 wt% of EOS-12 in E7 does not affect the mesomorphic properties of E7. Indeed, E7 doped with chiral molecules does not present significant modifications. When examined by POM between untreated glass substrates, the nematic phase of E7 exhibits a typical Schlieren texture slightly birefringent. Upon adding 2 wt% of compound EOS-12, a transition from the nematic phase to chiral one (N-N*) close to the clearing point (59.8°C) was observed. At this point, the marble

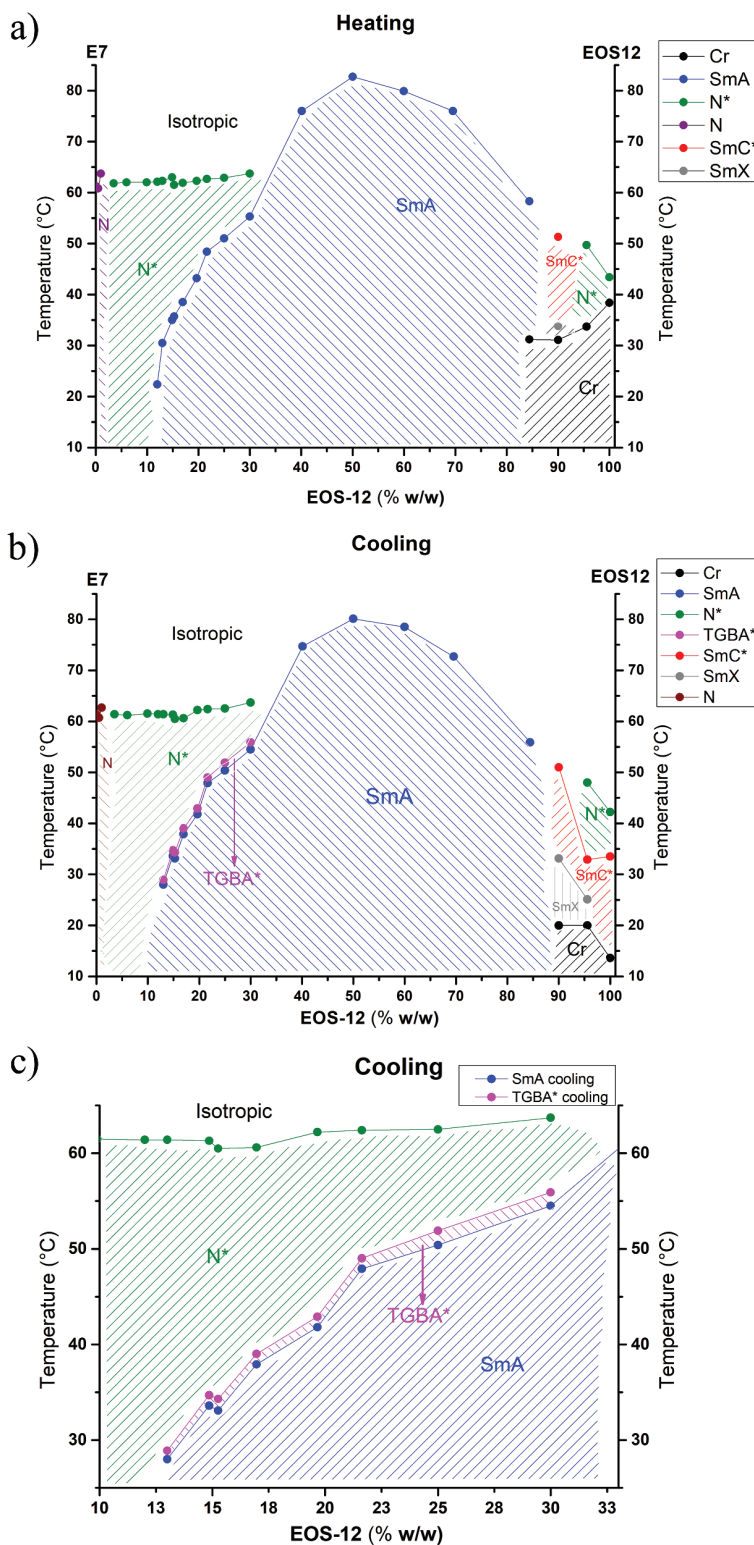


Figure 2. (Colour online) Temperature-concentration phase diagram of EOS-12/E7 mixture showing polymorphism as a function of the concentration (a) by heating, (b) by cooling. (c) Magnification inset displays the transition zone N*-TGBA*-SmA by cooling.

texture observed at room temperature was completely spread over the fingerprint texture. By cooling in the isotropic-nematic transition, nematic drops were observed with printed lines transformed into fingerprints.

This texture coexists with the Schlieren texture, as shown in Figure 3(a). This transition N-N* was also observed in the mixture at 3.5 wt% at 58.3°C, just before the clearing point. If the mixture is heated above the N-N* transition

temperature without reaching the isotropic state and then cooled, the reversible transition without hysteresis appears. Under the $N-N^*$ transition temperature, chiral and non-chiral domains were observed. If the sample is mechanically rubbed, only the non-chiral marble texture exists. It is worth mentioning that the marble texture cannot be found in pure E7. In the range of 6 to 10 wt%, the mixtures showed only the chiral nematic mesophase. The chiral nematic mesophase was identified, in all cases, due to the characteristic textures such as fingerprint (Figure 3(b,c)) or oily streak textures that were also obtained. By cooling, it was also possible to observe the pseudo-focal-conic or even pseudo-focal-conic texture with printed lines (Figure 3(d)).

From 12 to 30 wt%, the appearance of an enantiotropic SmA mesophase was observed. This mesophase SmA exhibited a conical focal texture (Figure 3(e)), and some

homeotropic zones can also be seen when the mixture was cooled. The SmA- N^* transition temperature increases as long as the percentage of EOS-12 increases in the mixture, reflecting a stabilisation of the SmA phase (Figure 2). With the typical filamentous texture in this same concentration range, a frustrated monotropic phase TGBA* also appears only by cooling (Figure 3(f)). Amplification of the phase diagram, Figure 2(c), shows a part of the temperature interval in which TGBA* is observed. This interval did not exceed 1.1°C. In addition, mixtures containing between 40 and 85 wt% of compound EOS-12 exhibit a direct transition from the SmA phase to the isotropic liquid without mediation by the chiral nematic phase. The phase diagram shows the SmA*-I transition by heating and cooling as a blue circle. Note that increasing the concentration of EOS-12 amount produces a hysteresis in the transition

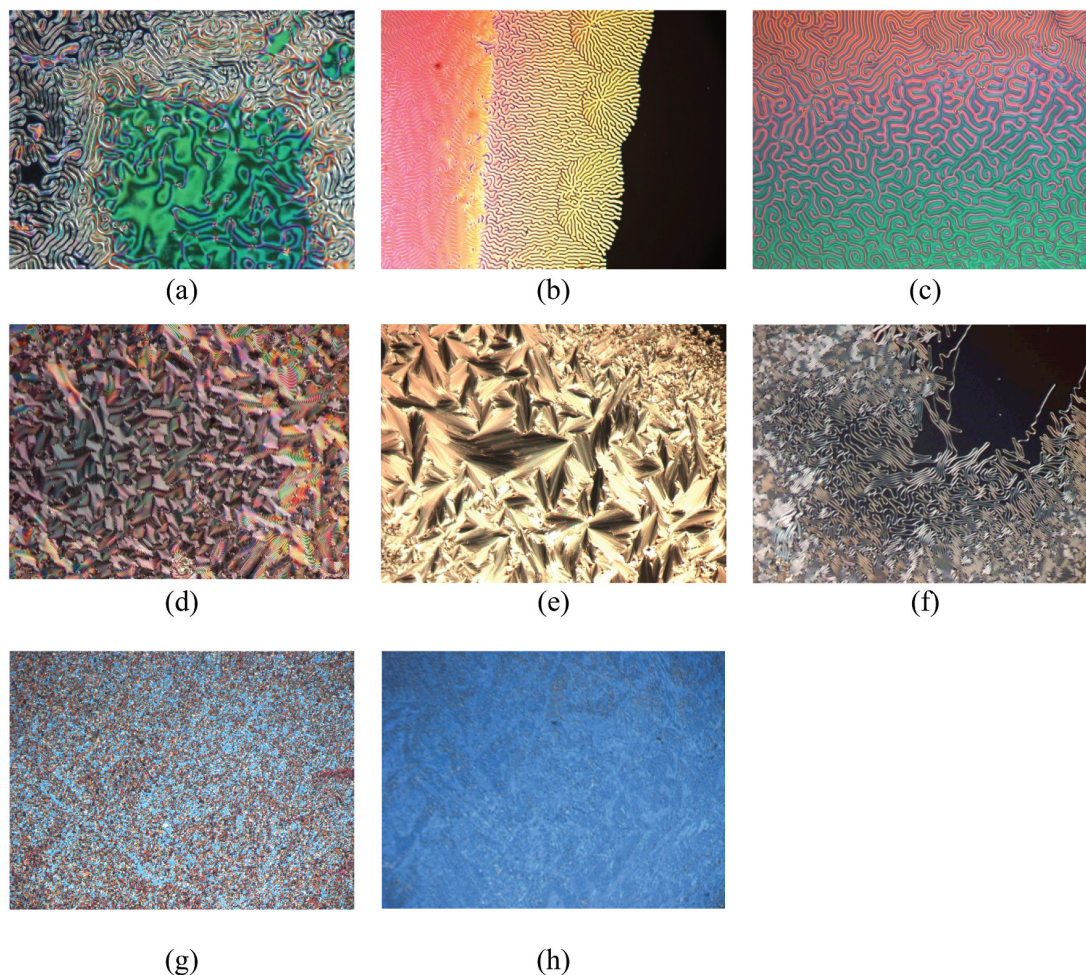


Figure 3. (Colour online) Micrograph of typical textures of different mixtures: (a) Schlieren texture with fingerprint for 3.5% EOS-12 by cooling at 59.3°C. (b) fingerprint texture for 15% EOS-12 by cooling at 36.4°C. (c) fingerprint texture for 15% EOS-12 by heating at 40.4°C (d) pseudo-focal conical with printed lines for 22% by cooling at 48.5°C. (e) conical focal for 17% EOS-12 by cooling at 30.8°C. (f) the filament texture of TGBA* for 20% by cooling at 47°C. (g) broken fan-shaped and pseudohomeotropic texture of SmC* for 90% by cooling at 40°C. (h) cloudy texture of SmC* for 90% by cooling at 46°C.

temperatures. Mixtures over 85% not presented the SmA phase. An enantiotropic SmC* mesophase is observed at 90 wt% of EOS-12 (Figure 3(g,h)). This result is very interesting because this mesophase was only observed by cooling in the pure compounds. In addition, a more ordered mesophase, SmX, was observed. At 95 wt%, however, the SmC* mesophase was monotropic once again, appearing only by cooling. By heating, the chiral nematic phase was exclusively observed. This mixture shows the same behaviour as pure EOS-12, with slight variations in transition temperatures and a wider mesomorphic range at 11°C. Pure EOS-12 exhibits an enantiotropic chiral nematic (N*) phase. On cooling, a monotropic chiral smectic C (SmC*) phase was also observed. Further decreasing the temperature ($T < 14^\circ\text{C}$), EOS-12 presents a transition from the monotropic chiral smectic C to the crystalline phase (Cr) [23]. On the other hand, an overall stabilising effect of the mesomorphic range was registered with the mixture at 50 wt%. At this concentration, the highest isotropisation temperature was observed. This result indicates a strong interaction between EOS-12 and the E7 mixture components.

In brief, in the mixtures, the nematic phase of E7 was replaced by a chiral nematic phase. This chiral nematic phase disappeared as the concentration of EOS-12 increased, whereas smectic A was the only stable phase observed over 35% wt. The preference for the SmA over other smectic phases or even chiral nematic phases, can be explained by the extensive out-of-layer fluctuations.

In previous reports, Kapernaum et al. [26,27] demonstrated that molecules in an orthogonal SmA phase could easily propagate into the next layer. This propagation is favourable for the structures of molecules of different sizes, in which such out-of-layer fluctuations are essential to fill the free volume between the molecules. In our case, the extended conformation of the smallest molecule is 15.6 Å in length and 39.7 Å in EOS-12, which is more than twofold in size; therefore, we might be observing this kind of phenomenon. On the other hand, in earlier studies, the EOS-12 compound's spontaneous polarisation was attempted to be measured, but due to the monotropic nature of the SmC* phase, the compound only crystallised when an electric field was applied. Interestingly, 90% of EOS-12 in the E7 mixture exhibited an enantiotropic SmC* phase. This finding provides an opportunity to study the ferroelectric properties of the substance. These studies are likely to be conducted in the future.

Differential scanning calorimetry analysis

The thermal analysis of differential scanning calorimetry allows obtaining information on phase transition as a function of enthalpies differences or changes in specific heat. Microscopy were carried out in conjunction with calorimetry in order to check that each thermal event in the DSC is matched by a change in optical texture. Figure 4 shows the results of some mixtures

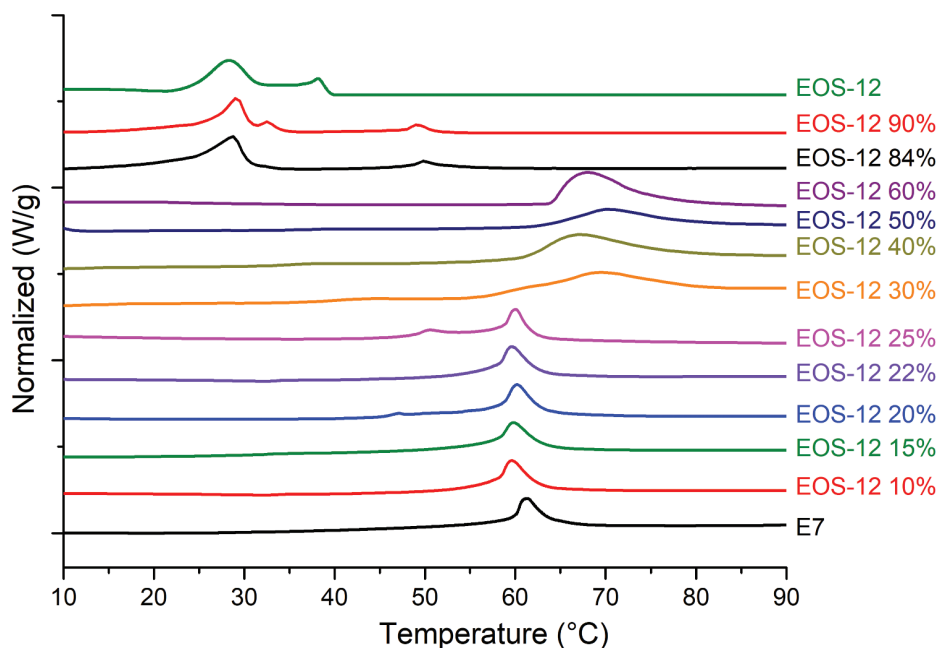


Figure 4. (Colour online) Differential Scanning calorimetry during the second heating cycle at $10^\circ\text{C}/\text{min}$. Different colour curves account for mixtures of 10–90 wt% EOS-12 with their respective concentrations. Pure EOS-12 and E7 curves have been added for comparison.

with concentrations ranging from 10 to 90 wt% of EOS-12.

The transition temperatures detected were concordant with those found by POM. The SmA-N* transition is easily observed during heating and cooling. Nevertheless, by POM, it is also possible to detect a change in the texture associated with the TGBA* texture between the SmA and N* transition in the cooling process. This mesophase was observed in mixtures between 12 wt% and 30 wt%. This second-order transition was not detected by DSC.

Chiral nematic phase characterisation

Nematic liquid crystals doped with chiral agents exhibit macroscopic helical order [6]. The chiral nematic self-organisation is characterised by the cholesteric pitch and the handedness of the helix [6,28]. Most cholesteric liquid crystal devices exploit the change in the light transmission and reflection that the cholesteric pitch undergoes when an external stimulus is exerted on the material [29], making the cholesteric pitch a fundamental characteristic of any novel chiral liquid crystal.

In this study, the cholesteric pitch is measured by using the Grandjean-Cano technique [28]. The texture observed under crossed polarisers displays discontinuous lines associated with discontinuous pitch jumps, as shown in Figure 5(a), in the temperature range where the N* phase is stable (see Figure 2(a,b)). The width between the Grandjean lines combined with the curvature radius of the cylindrical lens allows for measuring the cholesteric pitch [28]. The method is repeated for different concentrations of EOS-12 ranging from 10 wt% to 25 wt% at 57°C, using planoconvex cylindrical lenses of curvature radii from 10.3 to 25.8 mm. Figure

5(b) summarises the relationship between the EOS-12 concentration (c) and the pitch (p). The fitted red curve is $p = 1/\beta c$, where β is the twisting power of the chiral dopant [30]. The divergence of the characteristic helical length towards lower concentrations is expected because the N phase can be thought of as an N* phase with infinite pitch. The power-law behaviour is responsible for restricting the analysis only to EOS-12 concentrations between 10 and 25 wt%. Below 10 wt%, the pitch is too large and does not fit into the samples considered here. Rotation of the analyser in a clockwise direction moves the Grandjean lines towards increasing thickness, which means that the N* phase is right-handed [31].

The cholesteric pitch can also be tuned by temperature. Temperature variations can trigger winding/unwinding transitions [32]. Figure 5(c) shows the temperature dependence of the pitch for a mixture with 25 wt% of EOS-12 under a cylindrical lens (curvature radius of 39.1 mm). The increment of the cholesteric pitch when cooling the sample is associated with the emergence of the ordered SmA phase [33]. The distance between the Grandjean lines becomes wider (see insets in Figure 5(c)), and they move towards increasing thickness until they disappear (helix unwinding). This N*-SmA transition appears to be of second order, characterised by the smooth disappearance of the discontinuity lines.

Digital colourimetry analysis

A liquid crystal phase transition can be studied with different complementary techniques to evaluate its behaviour. The interaction between light and liquid crystals can be used to characterise transitions from SmA-N*, including a frustrated TGBA* mesophase [7].

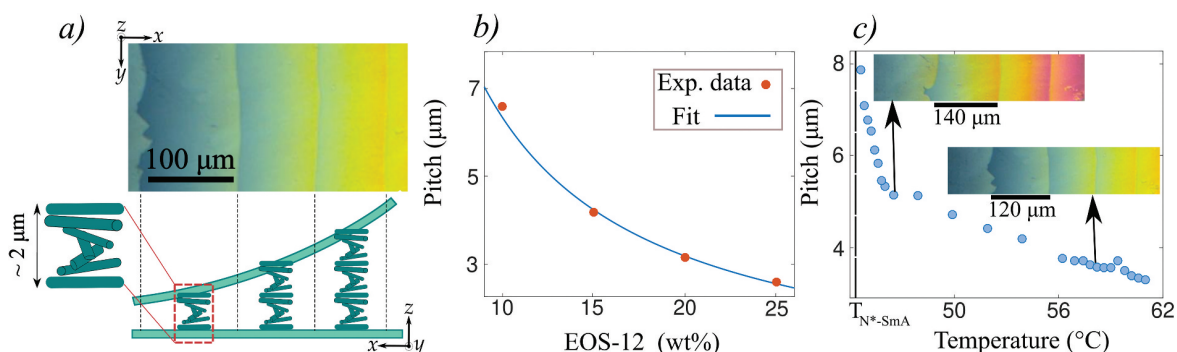


Figure 5. (Colour online) Characterisation of the cholesteric pitch by Grandjean-Cano method. (a) the upper panel shows the discontinuity lines in a mixture with EOS-12 at 20 wt% under crossed polarisers. The lower panel illustrates the pitch quantisation. The green tubes represent the average molecular director. (b) Variation of the pitch (p) with the concentration of the chiral dopant EOS-12. The fit $p = 1/\beta c$ (blue curve) gives a twisting power of $\beta = 3.5 \mu\text{m}^{-1}$, with an R-squared of 0.995. (c) Temperature dependence of the pitch in a mixture of EOS-12 at 20 wt%. The insets show Grandjean lines at different temperatures (47°C and 57°C). The transition N*-SmA ($T_{\text{N}^*\text{-SmA}}$), by cooling at a constant rate of 1°C/min, occurs at 44°C.

An image can be analysed in function of a different colour representation system, such as red-green-blue (RGB), cyan-magenta-yellow-key (CMYK), and hue-saturation-lightness (HSL), among others [34,35]. HSL system has been used in the reflection analysis of cholesteric mesophases [32,36,37]. Namely, this colour representation provides information on the interaction of light with objects to analyse. Digital colourimetry analysis has been also used to characterise other bifurcations [25].

A complementary analysis of phase transition SmA-N* in planar cells, through the treatment of images obtained from a digital camera and their transformation to the HSL colour system were realised. This tool allows the evaluation of some phase transition characteristics in liquid crystals based on some parameters (HSL) obtained under polarised light. In this case, lightness was chosen to characterise phase transitions. The

lightness is related to the intensity of light sensed by the camera. Indeed, changes in textures and lightness allow determining the different phases and complementary information of their transitions in the liquid crystal cells. It should be noted that this technique does not provide information about the energy changes involved in the processes. Figure 6 shows the results obtained in a cell of 20 μm with a planar alignment for two concentrations of EOS-12, 25 and 13 wt%, respectively.

Figure 6(a) shows a constant lightness value in the range of the Smectic A mesophase. Close to the transition (52.6°C), the lightness had an abrupt change to a maximum value and then fell. This modification is a manifestation of the phase transition. The molecular positional order at this temperature disappears, and only the orientational order remains. The anchoring of cells competes with the molecules' elasticity. Also, the molecular pitch of the helical self-organisation changes

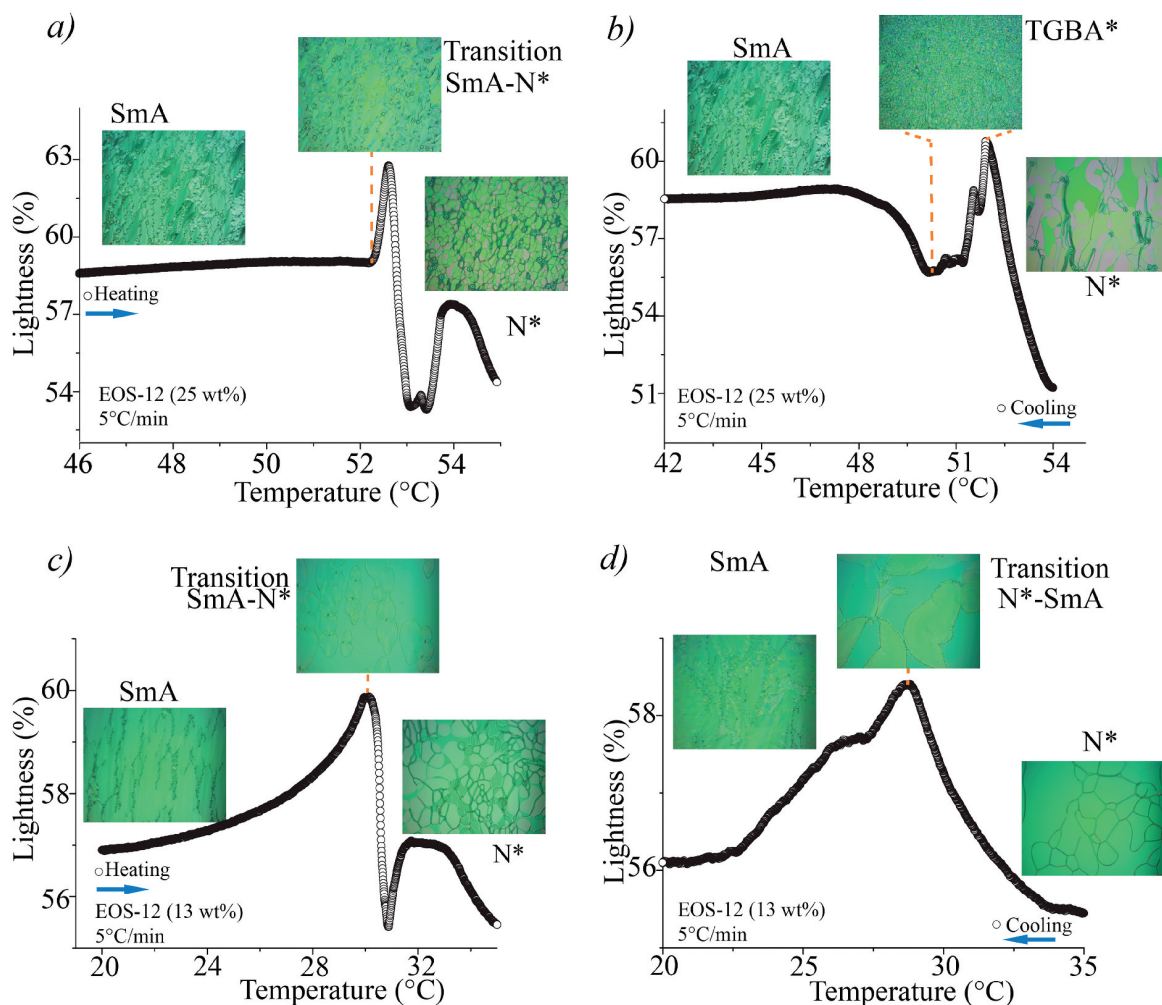


Figure 6. (Colour online) Temperature-dependent lightness in planar cells for phase transition detection. The lightness was obtained by digital colourimetry analysis. Samples of EOS-12/E7 (EOS-12, 25 and 13 wt%) in a cell of 20 μm were studied by heating (a/c) and cooling (b/d) at a rate of 5°C/min. Insets correspond to the typical snapshots at their respective temperature of mesophases.