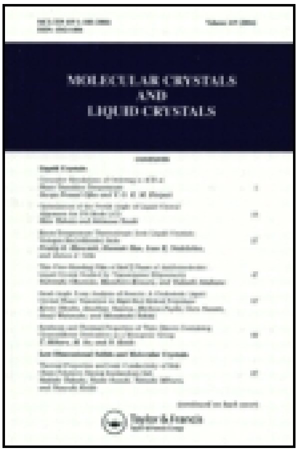

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An Influence of Nematic Medium on Helical Twisting Power of Chiral Compounds

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In this paper four optically active dopants with high Helical Twisting Power are investigated. Chiral compounds were tested in two kinds of achiral mixtures with broad temperature range of the nematic phase. The mixtures have been chosen considering different kind of polar group substitution in their components molecules and therefore their different dielectric anisotropy.

Keywords Chiral; cholesteric; helical pitch; Helical Twisting Power; nematic

1. Introduction

Chiral liquid crystalline materials have been attracting interest of the researchers around the world due to their technological applications e.g., in liquid crystal display technology or optical tunable filters [1]. Chiral phases can be observed in chiral mesogenic compounds or mixtures of achiral liquid crystalline materials and chiral compounds. Different parameters seem to be responsible for inducing the helicity in an achiral phase. In the course of this induction molecular chirality of a dopant is transferred to liquid crystalline material causing change in size and sense of helical pitch. This transfer is dependent on the interactions between molecular structure of the chiral dopant and the properties of its surrounding [2]. One of the parameters that informs us of chiral dopants ability to induce the helical structure in an achiral liquid crystalline host is Helical Twisting Power, calculated by the equation HTP $(\mu m^{-1}) = 1/(Pcr)$, where P (μm) is the helical pitch length, c (mol/mol) is the molar ratio of chiral dopant and r is enantiomeric excess [3–5]. The object of this paper is to show the dependence of Helical Twisting Power on structural properties of chiral dopant and type of achiral matrix.

2. Materials

Two kinds of achiral nematic materials with crystal-nematic transition below $-10°C$ have been chosen. Their components represent two different types of molecular structures of nematic materials. The first one is 1816 nematic mixture (Table 1) with

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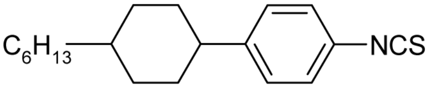
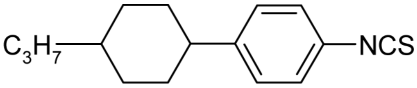
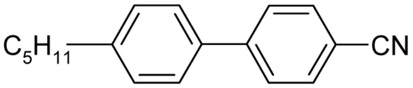
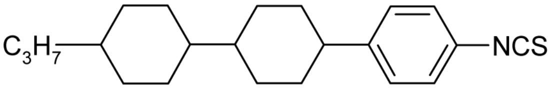
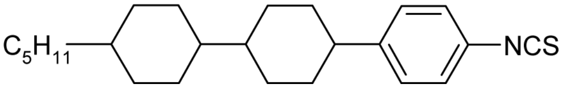
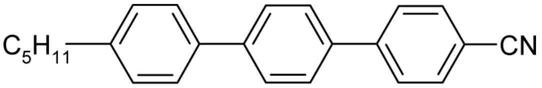
Table 1. The 1816 nematic mixture composition

Compound structure	Weight ratio (%)
	22
	24
	24
	19
	6
	5

positive dielectric anisotropy and nematic-isotropic transition at 87.6°C. It is composed of terminally substituted isotiocyanates. The second one is 1781 nematic mixture (Table 2) with negative dielectric anisotropy and nematic-isotropic transition at 94.8°C, composed of laterally fluorosubstituted terphenyls.

Four compounds were used as a chiral dopants (Table 3): two of them (OAD 66 and OAD 44) with chiral groups at each end of the molecule and two (OAD 5 and OAD 3) with chiral group in the centre of the molecule (Table 3). Dopants were chosen because of their potentially high Helical Twisting Power and in consequence the possibility of obtaining measurable data while using their small weight ratio percentage.

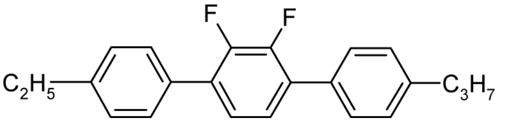
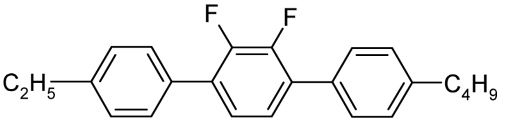
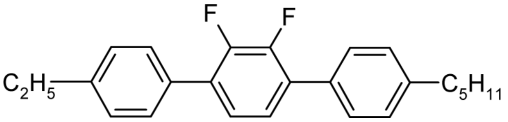
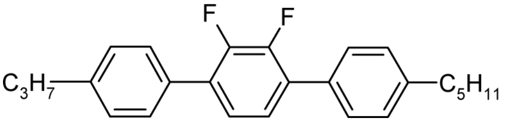
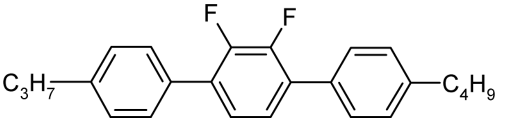
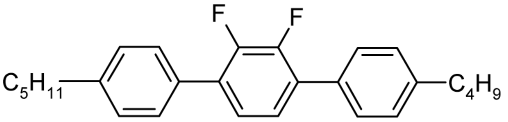
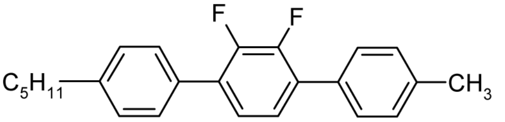
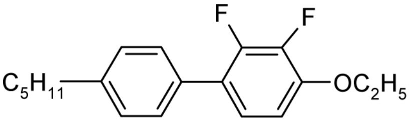
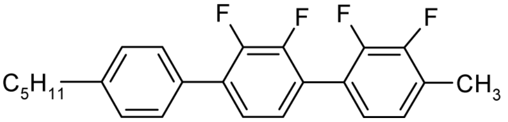
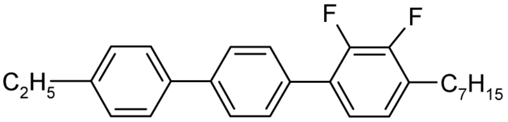
3. Experimental

Mixtures with 10% weight ratio of optically active dopant have been prepared. Their cholesteric – isotropic transitions have been indicated (Fig. 1).

For two kinds of our chiral dopants enlargement of the alkyl chain causes different effects while considering the cholesteric-isotropic transition. For compounds OAD 66 and OAD 44, longer alkyl chains at the end of molecules causes lowering of the induced cholesteric phase temperature ranges. For compounds OAD 3 and OAD 5 the effect of alkyl chain enlargement is opposite. This effect is present in the both modified base mixtures.

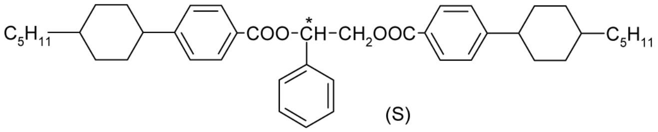
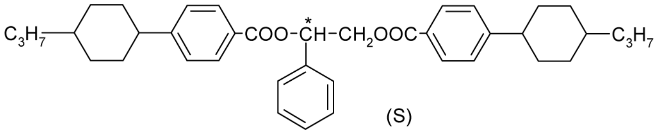
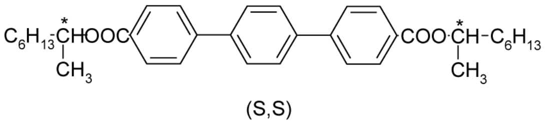
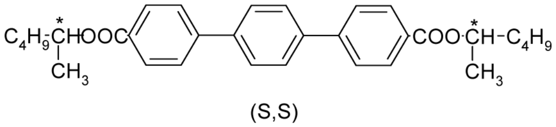
The helical pitch has been measured by means of selective light reflection method. The samples have been put between two glass plates without any surface treatment inside a Peltier cell. To provide the planar alignment of molecules, the liquid crystal sample is heated to the isotropic phase on a single glass plate, cooled down, and when the transition to cholesteric phase starts the second plate is put on top. The cell has been placed into UV-3600 Shimadzu spectrophotometer with

Table 2. The 1781 nematic mixture composition

Compound structure	Weight ratio (%)
	9
	13
	19
	8
	9
	13
	6
	12
	6
	5

a temperature controller. The measurements were conducted with 5°C step at the cooling. Helical pitch P (μm) has been calculated according to the equation $P = \lambda_{max}/n$ where λ_{max} (μm) is the selectively reflected light wavelength, and n is the average refractive index. The average refractive index of the base mixtures is 1,5 and modification of the mixtures with chosen chiral dopants have a very small

Table 3. Optically active dopants structures and abbreviations

Compound structure	Abbreviation
	OAD 5
	OAD 3
	OAD 66
	OAD 44

effect on it. The results of modification of nematic mixture 1816 are shown in Figure 2.

In Figure 2 it is noticeable that for both types of chiral compounds longer alkyl chain increases the Helical Twisting Power. This effect has a smaller magnitude for compounds with chiral groups at the ends of the molecule than for compounds with one chiral group at the centre of the molecule. It is easy to observe that the obtained diagrams exhibit Helical Twisting Power almost constant with temperature for all of the chiral dopants, however the mixtures modified with OAD 66 and OAD 44 induce helical structure that exhibits the smallest changes with temperature. This

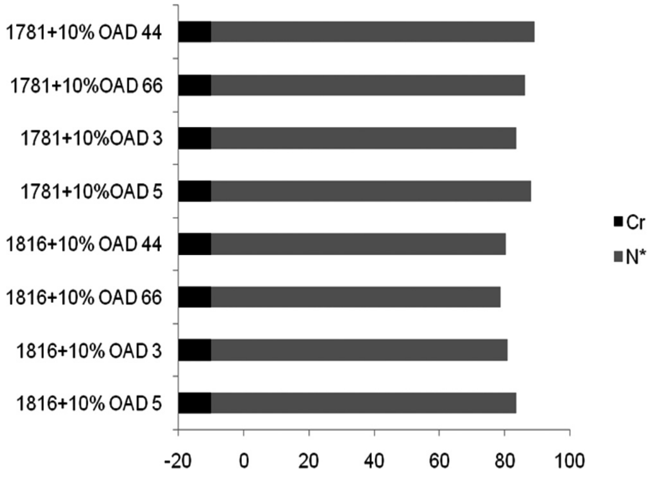


Figure 1. Phase transition temperatures for the mixtures studied.

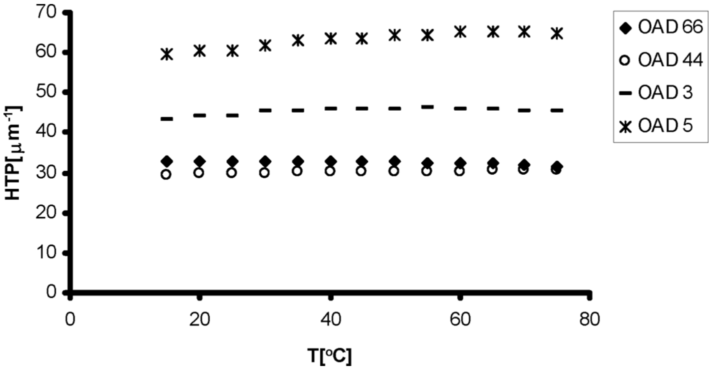


Figure 2. Temperature dependence of HTP for modification of 1816 nematic mixture.

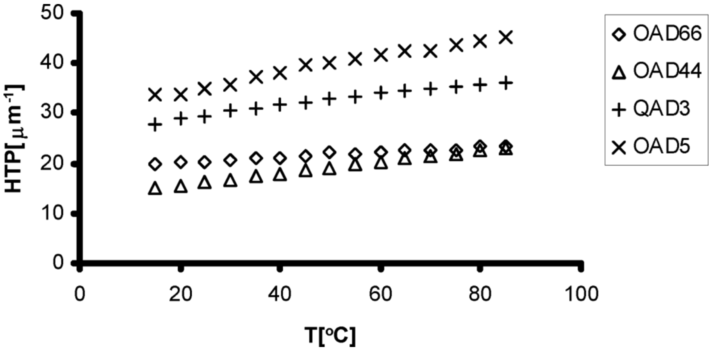


Figure 3. Temperature dependence of HTP for modification of 1781 nematic mixture.

is favorable for application in optoelectronic devices that need to work in a broad range of temperatures.

Figure 3 shows the same kind of dependence of HTP for modification of the mixture 1781.

The values of the Helical Twisting Power in the mixture 1781 are lower than in the mixture 1816, and they increase with temperature rising. We can also observe smaller difference between the Helical Twisting Power of OAD 3 and OAD 5 and greater difference between HTP of compounds with chiral groups at the end of the molecules. In both cases, compounds OAD 5 and OAD 3 have higher potential for inducing helical structures than the compounds OAD 66 and OAD 44. Also the compounds with longer alkyl chains have higher Helical Twisting Powers in the both base mixtures.

4. Conclusions

The results show that longer alkyl chains in chiral dopants give higher Helical Twisting Power in the case of nematic medium. This can prove that chiral compounds with longer molecular axis create stronger interactions between molecules of an achiral base mixture. It is observed that the chiral group placed in the centre of the molecule gives higher HTP than the chiral groups at the end of the molecules. This might be caused by the fact that a part of the chiral molecule surrounding the chiral centre has higher mobility in compounds OAD 3 and OAD 5 than in compounds OAD 44 and OAD 66. Higher sensibility to helical structure formation of the nematic mixture 1816 can be caused by the linear shape of its molecules, undisturbed by substituents in the rigid core (as in the components of mixture 1781). It is possible that HTP can be higher in the mixture 1781 for different kind of chiral structures. It is also observed that modification of the 1816 nematic mixture gives almost constant HTP, especially with OAD 44 and OAD 66. This may lead to a conclusion that in terms of modeling of materials properties, the base mixture is equally important as the chiral dopant used. This research provides a wider scope of formulating materials for technological applications.

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