



Production of functional liquid crystalline materials for color LCD displays and investigation of electro-optical properties

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Liquid crystal cells of 4-octyl-4-biphenylcarbonitrile (8CB) nematic liquid crystal with pure and different concentrations of Copper(II) phthalocyanine (CuPc) have been prepared by capillary method. The color liquid crystals were prepared using Copper(II) phthalocyanine (CuPc). The composite liquid crystals have been analyzed by dielectric and optic spectroscopy method. The dielectrical properties of the composites were investigated in the 0-1000 kHz frequency range at room temperature. It was found that CuPc doped 8CB nematic liquid crystals have a positive dielectric anisotropic behaviour. The dielectric anisotropy of the 8CB liquid crystal was decreased as the molecular state changed with the change of CuPc amount. The obtained results show that the dielectric anisotropy behaviour of composite liquid crystals are-controlled by organic materials.

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1. Introduction

Matter exists in four basic phases: solid, liquid, gas and plasma. Atoms have different degrees of freedom, distributions and symmetries in each phase. Based on the molecular order, it is seen that matter is not limited to solid, liquid, gas and plasma states. Some matters show intermediate phases of molecular arrangement between solid and liquid instead of going directly from solid to liquid state when heated. Because of these properties, these materials are called liquid crystals [1,2].

The liquid crystal phase is defined as a new phase of matter that contains the anisotropic properties of solids and the isotropic properties of liquids. Due to the anisotropic properties of liquid crystal structures, some physical

properties may differ when measurements are made in different orientations [3], [4]. Liquid crystal structures,

which have weak intermolecular forces, can be easily manipulated by external effects such as electric field, magnetic field, temperature and pressure applied on them, and with these properties, they are used in various applications in the field of science and technology today. [2], [5], [6].

Liquid crystal structures are studied in two different groups as thermotropic and lyotropic. Interphases of thermotropic liquid crystals are formed by temperature and is divided into three different groups as nematic, smectic and cholesteric. Lyotropic liquid crystals, on the other hand, are formed by the combination of different organic compounds

at certain concentrations. Nematic liquid crystals are the most used structures in scientific research among liquid crystals. Molecular orientation of nematic liquid crystal structures can be easily changed by the effect of external forces (electric, magnetic, etc.).

These properties allow nematic liquid crystal structures to be used in many opto-electronic device applications [7,8] Also Copper phthalocyanine (CuPc) is a widely used organic semiconductor material. It shows very good optical, electrical, photoconductive and photovoltaic properties. [9].

Liquid crystals materials (LCs) have an important place in technological such as LCD televisions, calculators ,computers TV's, drug delivery applications, photonic implications, controllable lenses and lasing etc [10]. Especially Especially in several key areas of flat panel displays and fiber optic communications, liquid crystals have become very important. dielectric anisotropy properties will be determined for the investigation of liquid crystals [11].

In present study, the dielectric and optical properties of copper phthalocyanine doped 8CB liquid crystal were investigated by capacitance–voltage methods.

2. Experimental

The structural figure of 8CB nematic liquid crystal and CuPc, which is an organic semiconductor material, used in the study is shown in Figure 1. CuPc organic semiconductor materials were weighed depending on the amount of additive and the amount of matter was determined. Approximately 0.09 g of 8CB liquid crystal was dissolved in 2 ml of DMF (CH₃)₂NCH (Dimethylformamide) in ultrasonic bath. Then, 0.5ml 8CB/ 0.1ml CuPc, 0.5ml 8CB/ 0.2ml CuPc, 0.5ml 8CB/ 0.3ml CuPc, 0.5ml 8CB three composites were prepared from the liquid solutions prepared by dissolving approximately 0.002 g CuPc organic compound in 2 ml DMF in a separate container, respectively. It was mixed in vortex and ultrasonic mixers and subjected to heat treatment from time to time for better mixing. 8CB and CuPc doped 8CB liquid crystal samples are filled into the empty indium tin oxide (ITO) liquid crystal cell with the help of an injector and the capacitance-voltage measurements are shown in Figure 2. The dielectric anisotropy properties of the composite liquid crystals were done using a FYTRONIX FY-9000 IV and CV analyzer , shown in Fig.2

3. Results and Discussion

Dielectric properties measurements of the liquid crystals were performed by using Capacity-Voltage (C-V) method. $\Delta\epsilon$ -f characteristics of the liquid crystals are shown in Fig.3 a-d. The C-V results of the liquid crystals show that the dielectric properties of the 8CB and CuPc doped 8CB liquid crystals exhibit a positive dielectric anisotropy at all frequencies, $\Delta\epsilon > 0$. The 8CB liquid crystals exhibit a p-type dielectric anisotropy. Depending on the content of doping, dielectric anisotropy values are varied. It was found that the amount of doping increases the dielectric anisotropy value.

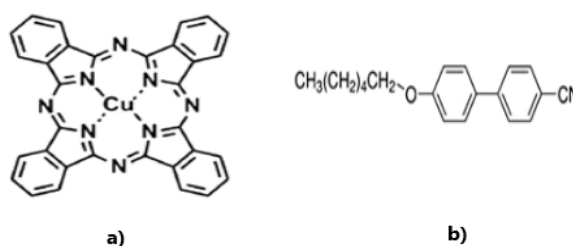


Fig. 1. Chemical structure of the materials used in the experiment a) CuPc b) 8CB

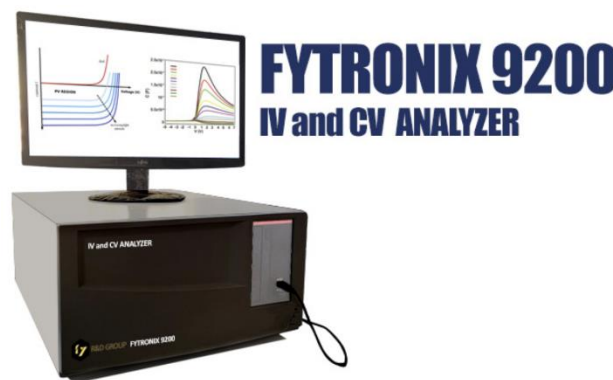
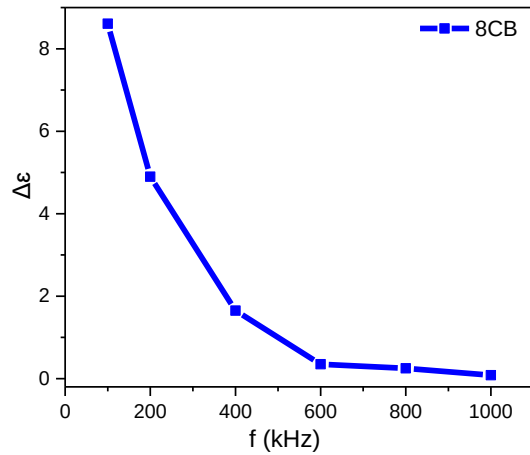


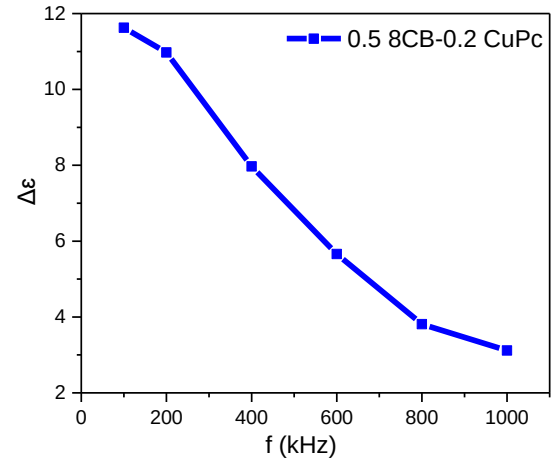
Fig. 2. FYTRONIX FY-9000 IV and C-V analyzer

2.1. Dielectric anisotropy properties of composite liquid crystals

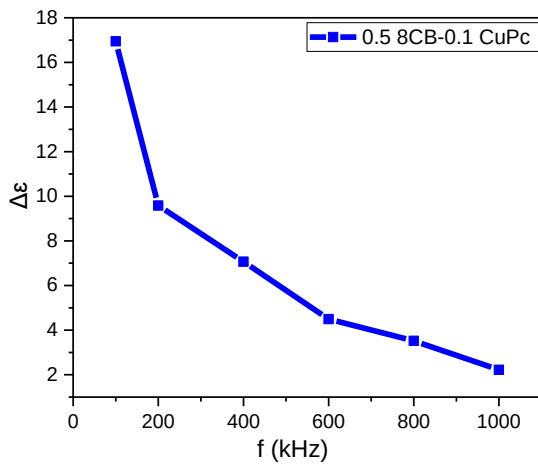
The dielectric anisotropy of 8CB liquid crystal is increased as the molecular state changes with the change of CuPc amount. The change in molecular state is attributed to polarization of the molecules under the influence of strong dipolar interaction between CuPc and 8CB liquid crystal.



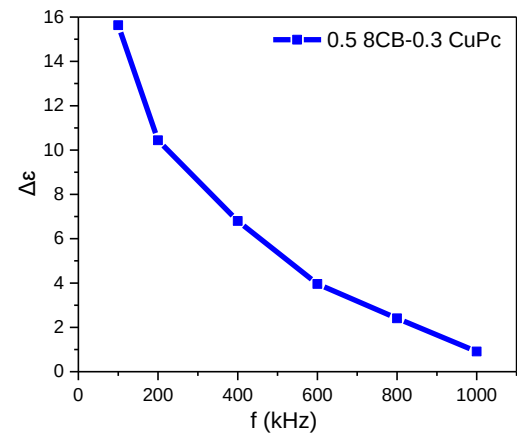
a)



c)



b)



d)

Fig.3. $\Delta\epsilon$ plots of the 8CB and CuPc doped 8CB liquid crystals.

The CuPc doped 8CB liquid crystal cells can be polarized depending on the doping of organic materials. The optic properties of liquid crystals have been investigated by transmission method. The transparency of the liquid crystals were decreased with increasing doping content. In addition, the transmittance properties of liquid crystals were investigated. It was observed that the transparency of the liquid crystal cells was changed with the doping

4. Conclusions

The dielectric anisotropy properties of CuPc doped 8CB liquid crystals have been investigated. The color liquid crystals were prepared using CuPc organic semiconductor. The color of liquid crystal cells is changed from clear to blue. The obtained color liquid crystals cells can be used in LCD applications.

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References

- [1] Gülsüm Kocakulah, Düzce Üniversitesi Fen Bilimleri Enstitüsü Yüksek Lisans Tezi,

- CdSES/ZnS Kuantum Nokta Katkılı 5CB Nematik Sıvı Kristalinin Elektro-Optik Ve Dielektrik Özelliklerinin İncelenmesi, (2018).
- [2] H. J. Shah, "Engineered interfaces for liquid crystal technology," Ph.D. dissertation, Department of Electrical Engineering, Drexel University, Philadelphia, PA, USA, 2007.
- [3] O. Köysal, "Azo boya ve fullerene (C60) katkılı nematik sıvı kristallerin elektro-optik özelliklerinin incelenmesi," Doktora tezi, Fizik Bölümü, Gebze Yüksek Teknoloji Enstitüsü, Kocaeli, Türkiye, 2007.
- [4] P. K. Tripathi, "Electrical and optical studies of some liquid crystals," Ph.D. dissertation, Department of Physics, Lucknow University, Lucknow, UP, India, 2013.
- [5] G. Pathak, S. Pandey, R. Katiyar, A. Srivastava, R. Dabrowski, K. Garbat, and R. Manohar, "Analysis of photoluminescence, UV absorbance, optical band gap and threshold voltage of TiO₂ nanoparticles dispersed in high birefringence nematic liquid crystal towards its application in display and photovoltaic devices," *Journal of Luminescence*, vol. 192, pp. 333–339, 2017.
- [6] S. Singh and D. A. Dunmur, *Liquid Crystals: Fundamentals*, Singapore: World Scientific Publishing, 2002.
- [7] O. Köysal, M. Okutan, and M. Gökçen, "Investigation of dielectric properties and diffraction efficiency enhancements caused by photothermal effect in DR9 dye-doped nematic liquid crystal," *Optics Communications*, vol. 284, pp. 4924–4928, 2011.
- [8] Mustafa İlhan, Fırat Üniversitesi Fen Bilimleri Enstitüsü Yüksek Lisans Tezi, Lcd Ekranlar İçin Nanomalzeme Esaslı Sıvı Kristallerin Üretilmesi, (2014).
- [9] Faten Al-Hazmi, Ahmed A. Al-Ghamdi a, Noruh Al-Senany , Fowzia Alnowaiser ,Fahrettin Yakuphanoglu, Dielectric anisotropy and electrical properties of the copper phthalocyanine (CuPc): 4–40-n-Heptylcyanobiphenyl (7CB) composite liquid crystals, *Composites: Part B* 56 (2014) 15–19.
- [10] Burhan Coşkun, Molecular structure and phase change properties of various polymer-doped liquid crystal, *Journal of Molecular Structure* 1191 (2019) 278e283.
- [11] F. Yakuphanoglu , M. Okutan , O. Koysal , S.-M. Ahn , S.R. Keum, Dielectric anisotropy, and diffraction efficiency properties of a doped nematic liquid crystal, *Dyes and Pigments* 76 (2008) 721e725.