Investigation the Influence of Carbon Monoxide on the Spectral Characteristics of Cholesteric Liquid Crystal-Fe_2O_3 Nanodopant System

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Abstract – **This work describe the results of spectral investigations of cholesteric liquid crystal-nanodopant Fe_2O_3 system under the influence of carbon monoxide. These investigations are useful to design the optoelectronic sensors of harmful gases.**

Key words – **Cholesteric liquid crystal, Fe_2O_3 nanodopant, sensors of harmful gases.**

I. INTRODUCTION

Operation of gas sensors based on the following methods as electrochemical, thermochemical, calorimetric, spectroscopic, and also on methods that use nuclear electronic resonance, as well as mechanical resonance. Relevant to the design of gas sensors is using the optical methods.

In recent years, liquid crystal (LC) materials are use as sensitive materials of environmental pollutants. Specificity of the LC material is that, on the one hand, there is orderly structure, and on the other hand – the material with extremely high sensitivity to changes of ordering under the influence of external factors. This is explained by the large optical anisotropy such kind of materials and it's easily registries optically [1]. Structure of the LC changes its properties under the action of external influences of different nature: temperature, electric and magnetic fields, radiation of different wavelengths, intermolecular interaction with the substrate, mechanical and even chemical factors that lead to changes the LC optical parameters. Thin films of liquid crystals absorb gases from the environment and change their optical properties.

II. EXPERIMENT

When passing through a layer of substance (solution) flux with intensity I_0 the intensity as a result of absorption in the layer, reflection and scattering is reduced to the value I. The relationship between the intensity of light streams I_0 and I set Lambert-Buhera law, under which homogeneous layers of substances having the same thickness absorb the equal share of the incident light energy to them (at a constant solute concentration). Mathematically, this law is expressed by the equation of exponential dependence:

$$I = I_0 \cdot e^{al} \quad (1)$$

where, *e* is the base of natural logarithms; *a* is absorption coefficient; *l* is thickness of the absorbing layer.

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Transmission of investigated sample is T, and it is the ratio of the intensity of the radiation flux I, passing through the measured sample to the intensity of the radiation flux I_0, which falls on the sample:

$$T = \frac{I}{I_0} \cdot 100\% \quad (2)$$

In most cases the value of transmittance is expressed as a percentage [2].

As the liquid crystal mixture was used such compositions which at room temperature had the green color to allow fixing color shift in the blue or the red spectral region. The mixture was based on EE1cholesteric liquid crystal. Selected material has high temperature stability.

Fe_2O_3 we used as nanodopant. The choice of nanodopant is determinate by analogy with biological objects, such as components of human blood – hemoglobin. The main requirement for nanodopant is to improve the interaction of carbon monoxide and ensure good solubility in the liquid crystal matrix. The concentration of Fe_2O_3 nanodopand is 3% in the liquid crystal matrix.

The typical "sandwich" liquid crystal cell (Fig. 1.) is used for the investigations of the spectral characteristics of cholesteric liquid crystal-nanodopant Fe_2O_3 system. Thickness of the liquid crystal layer ranged from 3 to 50 microns, the size it was determinate by dielectric spacers. Measurement of the transmittance spectra were carried out in the range 350-750 nm. To register for the experimental data was used multi-ADC-DAC LabJack U3 [3], which brought the data to a computer for further processing. Manage wavelength spectrophotometer by using specialized computer software.

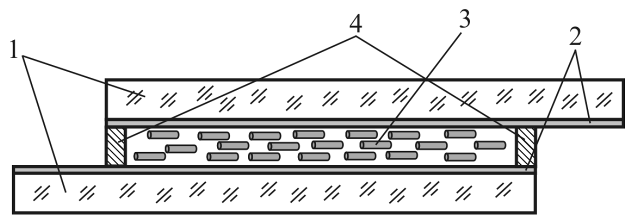

Fig. 1. The typical "sandwich" liquid crystal cell: 1 – glass substrates; 2 – transparent electrodes; 3 – liquid crystal layer; 4 – dielectric spacers

As the substrate we used two glass plates, which previously the planar orientation was setup. The cholesteric liquid crystal with Fe_2O_3 nanodopant spread on the one of the substrates at room temperature. After this investigation sample for a specified time was closed in the atmosphere of carbon monoxide. Then, using a second glass substrate the "sandwich" cell with investigated substance inside is formed [4, 5].

In Fig. 2, 3 show the transmission spectra of EE1 cholesteric liquid crystals with a concentration Fe_2O_3 nanodopand under and without the influence of carbon monoxide.

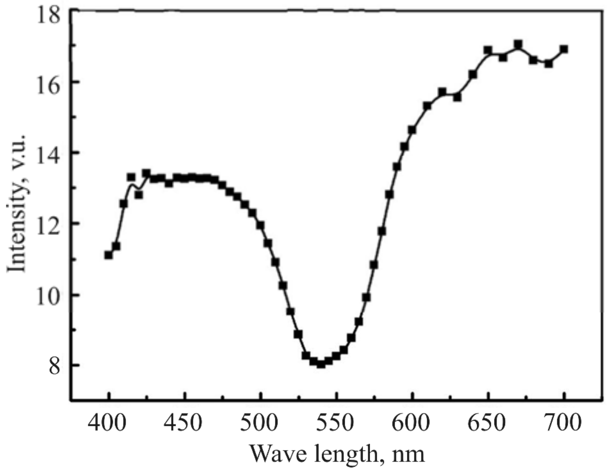

Fig.2. The transmission spectra of EE1 cholesteric liquid crystals with a concentration 3 % of Fe_2O_3 nanodopand

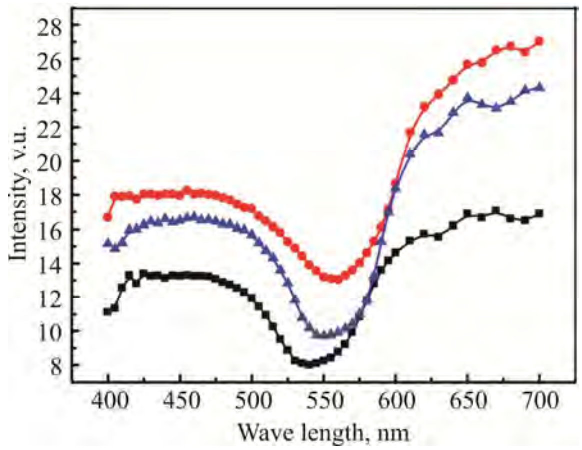

Fig. 3. The transmission spectra of EE1 cholesteric liquid crystals with a concentration 3 % of Fe_2O_3 nanodopand under the influence of carbone monoxide, (black line – without carbon monoxide influence, red line – 10 mg/m^3 of carbon monoxide, blue line – 20 mg/m^3 of carbon monoxide)

The investigation results of the spectral dependences showed a pronounced minimum of optical transmittance at a wavelength of 530 nm, corresponding to the green spectrum of EE1cholesteric liquid crystal-Fe_2O_3 nanodopant without influence of carbon monoxide (Fig.2.). With the influence of carbon monoxide (20 mg/m^3) for the system cholesteric liquid crystal-Fe_2O_3 nanodopant spectral characteristics of the investigation showed a shift of minimum of optical transmittance in the red spectral region at a wavelength of 570 nm (Fig. 3). This shift can be explained by the interaction of carbon monoxide with nanododopant Fe_2O_3, which leads to changes in spectral characteristics of the cholesteric liquid crystal mixture.

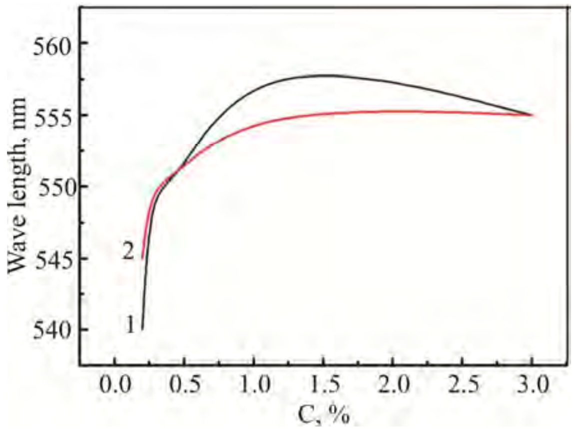

Fig. 4. The dependency of wave length of minimum of optical transmission versus concentration of Fe_2O_3 nanodopand in cholesteric liquid crystal with different carbon monoxide: 1 - 20 mg/m^3 2 – 40 mg/m^3

This change in spectral characteristics of cholesteric liquid crystal- Fe_2O_3 nanodopand can be used to design the optical sensor of carbon monoxide.

III. CONCLUSION

In work based on spectral investigations of cholesteric liquid crystal-Fe_2O_3 nanodopant systems shows possibilities of using such system as a primary transducer of optical sensors of carbon monoxide.

REFERENCE

[1] Z. Hotra, Z. Mykytyuk, O. Yasynovska "Temperature sensor on the base of light selective reflection". // *Elektronika, Poland*, 2008, N. 6. – P. 182-183.

[2] Vovna A. V., Zory A. A., Lykov A. G., Hlamov M. G. The mathematical model of the optical path for measuring concentration of carbon monoxide. // *Naukovi Pratsi DonNTU.* – 2010. – pp. 23-25. – Volume 169.

[3] Z. Hotra, Z. Mykytyuk, A. Fechan, O. Yasynovska, M. Skochelyas Initial Transducer of the Harmful Substances Sensors on the Basis of DFB-Lasers // *Selected Proceeding of the XXXII International Conference of IMAPS – CPMT IEEE*. Puitusk, Poland, 21-24 September 2008. – P.44.

[4] O. Sushynskyy, A. Rudyy, M. Chapran Optoelectronic sensors of carbon monoxide. *Advanced Numerical Modelling. – Warsaw-Lublin-Zielona Gora*, 2011. – P. 151-152.

[5] Z. Hotra, Z. Mykytyuk, O. Sushynskyy, O. Hotra, O. Yasynovska, P. Kisała Sensor systems with optical channel of information transferring // *Przegląd Elektrotechniczny (Electrical Review)*, R. 86. NR 10. – 2010. – P. 21–23.