Red blood cells aligning inside innovative liquid crystal cell

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Abstract. Investigation results of red blood cells (human erythrocytes) aligning and fixing inside the liquid crystal (LC) cell have been presented in the present paper. LC cells have been modified through the improved nanostructured relief and LC sensitized with intermolecular charge transfer complex COANP-C₇₀.

1. Introduction

Currently liquid crystal (LC) medium is used in broad areas of science and technology. It’s well known applying system based on LC in display technology, filters, limiters, etc. LC mesophase can be efficiently applied to solve biomedical problems such as the study and analysis of biological objects [1, 2] as well due to their aligning ability and unique combination of physical and chemical properties.

The size and the form of biological objects such as red blood cell, namely, the erythrocytes are important parameters for human disease diagnosis. It is well known that the normal erythrocytes are biconcave disk with diameter approximately 6–10 μm and a thickness at the thickest point of 2–2.5 μm and a minimum thickness in the centre of 0.8–1 μm [3]. The changes of colour, form and size of erythrocytes occurs during blood diseases, inflammation, etc. The erythrocytes investigation is conducted in two ways: using an automated analyzer and a haemocytometer. The most part of blood samples are examined by automated devices. This method allows carrying out analysis fast and accurate, but it monitors only cells of an average size and form. In the case of abnormal cells the manual method a haemocytometer is used. Haemocytometer consists of 2 glass substrates, one of which has a special chamber with a grid of perpendicular lines (figure 1). Number of blood cells is directly counted using a microscope for each lattice region and total count is performed using special math. The difficulty of performing a manual method consists in uncertainty of determining the position of cells located at the lattice region boundary.
The LC molecules ability to align red blood cells has been demonstrated in previous works [6, 7]. The experiments have been carried out in LC-cells with the thickness of 10 μm. Relief for LC molecule aligning has been made through polishing method of glass substrate by the polymer coating. LC cell content has been investigated via optical microscope. Photomicrography has demonstrated the areas of erythrocytes aligning and fixing. The interaction between a residual potential of erythrocytes membranes and uncompensated LC molecules dipoles has been considered as an aligning mechanism one. The feedback has been detected too: erythrocytes introduction resulted to LC selforganization and their division of the field domain. [8].

In the current paper both the sensitized LC medium with the increased polarization due to incorporation of the intermolecular charge transfer complex (CTC) and the nontoxic contactless laser oriented deposition (LOD) method to relief formation has been proposed. LOD method consists of deposition on the conductive ITO (indium tin oxide) layer covered with the carbon nanotubes (CNTs) additionally treated with the surface electromagnetic waves (SEW). Use efficiency of modified LC-cell to improve optical and photorefractive properties has been shown in work [9], the ability of LC polarization increase via intermolecular CTC introduction has been presented in papers [10, 11].

2. Experiments and Results
In the current work blood stable with sodium citrate has been added in concentration of 1:5 to mixture LC+COANP (2-cyclooctylamino-5-nitropyridine)+C_{70} in modified LC-cell. As a basic matrix LC from cyanobiphenyl class has been used. This matrix has been sensitized with the intermolecular complex based on COANP+fullerenes C_{70}. The influence of intermolecular CTC COANP+C_{70} on optical and nonlinear-optical medium properties has been shown in work [11, 12]. Intermolecular CTC COANP-C_{70} lead to LC selforganization and to transfer of the nematic LC phase to quasi-smectic one that influenced at transmittance, refraction and dynamics increase well. The transmittance growth and laser strength improvement of the LC cells with the modified relief via LOD applying have been described by the Fresnel losses decrease due to lower CNTs refractive index ($n=1.05$-$1.1$) and their high hardness [13]. Moreover, the relief with the CNTs modification can possibly reveal the disinfection of the biological mixture [14].

To confirm the erythrocytes orienting effect under the improved conditions explained above, the ocular micrometer has been used for the registration in this work. The obtained photomicrographs are presented at figure 2.

**Figure 1.** Haemocytometer: a) the parts [4] and b) grid [5].
Figure 2. Photomicrographs of the erythrocytes orienting effect existing in the modified LC-cell with blood in mixture LC+COANP+C\textsubscript{70}: a) selected area with aligning erythrocytes, b) increased erythrocytes image (the dimension is 31 μm).

One can see at the presented images the clear areas of aligning as blood cells and LC in a direction of created relief.

3. Discussion
To discuss erythrocytes aligning and fixing in LC-cell we should to observe the electrochemical property of their membranes which play important roles in interface. The membrane surface has a negative charge due to carboxyl group of sialic acid [15]. We consider the interaction between charged erythrocytes membrane and LC dipole with the increased polarizability. The increased polarizability has been obtained due to the intermolecular CTC COANP+C\textsubscript{70} incorporation in the LC matrix. This interaction between two charged items can be considered as a main mechanism for aligning of the human blood cells (figure 3).

Figure 3. Model of the interaction the erythrocytes-nematic LC molecule.

4. Conclusion
To summarize the results it can be concluded, for the first, the most successfully use of LC-cells with LOD modified relief (without toxic polymer layer) and, for the second, the predominant applying of the polarized LC with intermolecular CTC as well. These facts are important for the work with the bioobjects. The obtained aligning and fixing of the blood cells affect can be used for manual analysis of size and shape of erythrocytes as a human disease indicator under the express diagnostic conditions. Moreover, the procedure explained can be used for the DNA visualization and fixing as well.
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