

Структура електронного блока для спектрального ЕКГ-аналізу

### Результати розрахунку спектральних коефіцієнтів Фур'є при різних параметрах зсуву інтервалу аналізу ЕКГ (i)

Результати моделювання показали, що залежно від розмірності перетворення  $N$  можливо виявити такі зміни у положенні початку кардіоциклу:

$$N=32, dt=T/N = 0.8/32=0.25c,$$

$$N=512, dt=T/N = 0.8/512=1.5mc,$$

$$N=1024, dt=T/N = 0.8/1024=0.8mc,$$

тобто спектральними методами можливо виявляти навіть незначні зміни положення початку кардіоциклу (при  $N=1024$   $dt < 1mc$ ).

Процедуру спектральної обробки кардіосигналів для визначення змін ЕКГ при незначних відхиленнях початку кардіоциклу можна здійснювати програмними методами за допомогою спеціалізованих діагностичних комп'ютерних комплексів, або використовувати спецпроцесори для спектральної обробки сигналів у різних базисах [ 2], які можна вбудовувати у портативну апаратуру для експрес-аналізу кардіосигналів у вигляді додаткових електронних блоків.

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## ELECTROOPTICAL CHARACTERISTICS OF THE NOVELTY SYSTEM: IONIC DOPED LIQUID CRYSTAL – CONDUCTIVE POLYMER

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Fechan A., Konopelnik O., Fomenko V., Hlushyk I., 2004

Taking into account that ionic-doped liquid crystals are conductive and the conductance depends on dopant concentration, we suggested using ionic-doped liquid crystals as an electrolytic medium in a described configuration of cell. The application of an ionic doped liquid crystal as electrolytic medium in electrochromic device were investigated. Polyaniline is a conductive polymer and has electrochromic effect in an electrolytic medium under the applied voltage. The spectral investigation of the electrochromic effect of polyaniline was carried out in a new cell. The spectral dependences of such structure were presented on paper. An appearance of electrochromic effect was observed in a structure  $SnO_2$  – liquid crystal – polyaniline -  $SnO_2$ .

### 1. Introduction

It's known that electrochromic displays on the base of organic dyes harmonize with the background and are soft for human eyes, but their erasing-rewriting rate is slow [1]. This rate may be enhanced by

means of conducting polyaminoarene such as polyaniline with electroactive chromophore groups. Numerous investigations were carried out for electrochromic polyaniline films in organic and aqueous electrolytes [2,3], but the full polymeric electrochromic device operating on liquid crystal medium is not realized. In present report the electrochromic properties of polyaniline (PANI) have been studied as potential materials for application in two-electrode construction of electrochromic devices with ionic doped liquid crystal .

## 2. Experimental set up

It is known that in the usual nematic cells the electrooptic response does not depend on the sign of the applied electric field. In asymmetric cells, however, optical switching can be seen for only one direction of the applied field.

A way of getting asymmetric cells is to insert a thin layer of polyaniline (PANI) onto a conductive SnO<sub>2</sub> covered glass

The sandwich cell construction was used for such investigation. This cell consists of two glass plates with transparent conductive layers and polyaniline deposited by electrosynthesis method on one glass plate. The gap between plates was obtained by the dielectric polymer spacers of 20 μm thickness. This space was filled by liquid crystal medium.

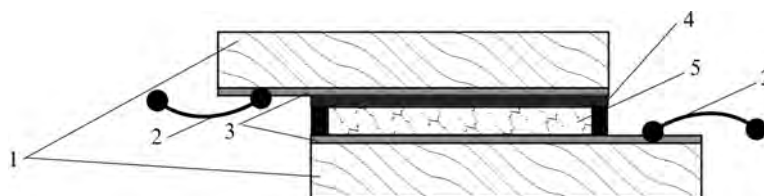


Fig. 1. Scheme of two-electrode electrochromic cell:  
1 – glass sheets; 2 – metal electrodes; 3 – transparent SnO<sub>2</sub> layer;  
4 – polymer film; 5 – liquid crystal

### 2.1. Polymer materials

Preparation of polyaminoarene films was carried out in three-electrode electrochemical cell by electrolysis of 0.1M solutions of purified monomer aniline in 0.5 M H<sub>2</sub>SO<sub>4</sub>. [4, 5] In this cell, the SnO<sub>2</sub> working electrodes, Pt-wire counter electrodes and Ag/AgCl (in saturated KCl) or Pt wire electrode as a references were employed. Film's thickness was measured by micro-interferometer MII-4. For polymer coated SnO<sub>2</sub> electrodes UV-viz. absorption spectra were obtained "in situ" in the range λ=320-1000 nm in quartz cell disposed in work camera of spectrophotometer SF-26 and connected with potentiostat PI-50M. Cyclic voltammetry experiments were carried out with potential sweep rate v=5-200 mV/s.

The microscopic investigation of polyaniline film was carried out. Obtained results give us information about surface morphology. As can be seen from pictures, the longer polarization time leads to more uniform and more developed surface (Fig.2.).

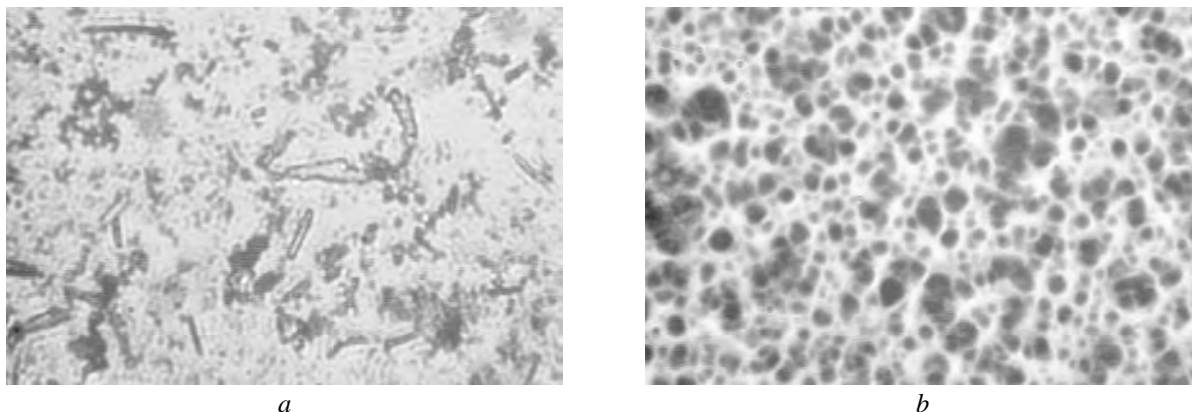


Fig. 2. Microscopy photos of polyaniline films obtained during different polarization time:  
a) 20 minutes; b) 30 minutes

It was found that under applying potential (0,1-2,0 V) in electron spectra of polyaminoarene films on SnO<sub>2</sub> surface the change of optical density and absorption band positions occurred. These variations were accompanied by reversible color transition from colorless to yellow, green, blue and violet (tabl. 1).

Table 1

**The potentials of electrochromic transitions  
in polyaminoarene films**

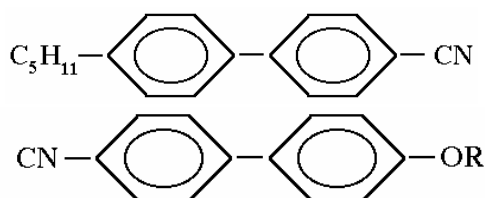
Conducting polymer layer on SnO <sub>2</sub>	Electrode potential, V (Ag/AgCl)												
	-0,2	-0,1	0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0
Polyaniline	transparent			yellow				green			purple		

Reducing of polymer layers at  $E = -0.2 \dots -0.1$  V leads to colorless form of poly-aminoarenes with absorption band at 340-420 nm ( $\pi-\pi^*$  transition). This band corresponds to leucoemeraldine benzenamine polymer with low conductivity [3]. The anode polarization of SnO<sub>2</sub> electrode to 0.2-0.6V causes the green color of the PANI film as shown in table 1. These transitions are accompanied by arising of a wide absorption maximum at  $\lambda = 700-850$  nm. For polymers with linear macrochain structure, such as PANI, absorption at 340-400 nm and at 700-800 nm may be assigned to polaron or bipolaron band.

But this construction uncomfortable for using and requires an additional device for reference electrode. This construction is however somewhat uncomfortable in practice (Fig.1). The operative voltage between two (SnO<sub>2</sub>-polymer/ SnO<sub>2</sub>) electrodes  $U$  is equal to  $\pm 4,0$  V.

## 2.2. Liquid crystal materials

The cell was filled with a nematic liquid crystal. As the objects of our studies, the systems based on mixtures of nematic substances were used. The origin components for nematic matrices synthesis were the mixture of cyanobiphenyles and oxycyanobiphenyles (SGK-1):



Tetrabutylammonium chloride was used as a ionic dopant.

In liquid crystal matrix, its give the conductivity of liquid crystal layer by thickness of 20  $\mu\text{m}$  was from  $5 \cdot 10^{-11}$  to  $10^{-7}$   $\text{Ohm}^{-1} \text{cm}^{-1}$ , and its depend on dopant concentration. In addition, the conductivity at ac voltage is 10 times lower than at dc voltage, that correspond near electrodes double charged layers, injection from electrodes and etc.

## 3. Results

Actually, as already reported, the polyaniline layer induces a homogeneously planar alignment of the liquid crystal molecules ( $\mathbf{n}$  parallel to the boundary surfaces) along a certain axis that depends on the process of sputtering. This direction was chosen to be perpendicular to the direction of filling the cell with the liquid crystal. The starting orientation of the NLC cell was set in such a way as to have a maximum of transmitted light when the cell was placed on the stage of a microscope between crossed polarizers.

The idea is that only in the case of anodic polarization there are transient currents injected into the cell which build up a sufficiently large surface charge. This surface charge—at the interfaces between the liquid crystal and the glass plates— produces an internal electric counterfield, which will inhibit the switching to the homeotropic state.

Yet the asymmetric behavior is given by a complex of synergic phenomena, including electrochemical, transport, and equilibrium statistical processes. A good understanding of this effect, apart from possible technical applications, would be beneficial to a wider spectrum of researchers from electrochemists and material scientists to liquid crystal device designers.

For the two-electrode electrochromic cell, the change in optical density in the range  $\lambda=450-1000$  nm was studied with monochromator KSVU-6.

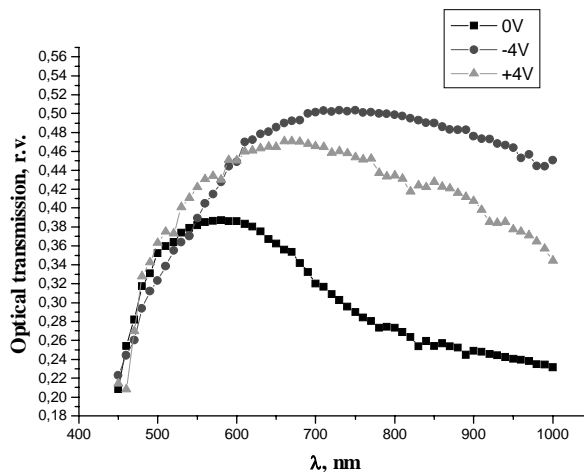


Fig. 3. Transition spectra of two-electrode optical elements with PANI-film in liquid crystal medium at  $U=0$ ;  $+4$  and  $-4V$

For characterization of electrochromic effect occurring in polymer films, the change of optical density (or transmission) with applied potential for different light waves correspondingly to absorption maximums were studied. It is found that under potential sweeping the more remarkable changes are observed for long-wave band at 700-850 nm, which perhaps was connected with change of free carriers concentration at switching potential (fig. 3).

The inhibiting switching configuration corresponds to anodic polarization of the trioxide film in which the deintercalation of cations occurs. Here we present the time behavior of charge and discharge for both the anodic and cathodic currents.

#### 4. Conclusion

Optical elements on the base of conjugated polyaminoarenes such as polyaniline and ionic doped liquid crystal medium exhibiting electrochromic effect were proposed.

The switching of optical elements by three-electrode scheme permits to accurate control of the color change and optical density of the films by the small change of working potential in relation to reference electrode.

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