U.P.B. Sci. Bull., Series A, Vol. 72, Iss. 3, 2010 ISSN 1223-7027

STUDIES ON THE MESOMORPHIC STATE OF THE STEARIC ACID

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În articol se prezintă un studiu asupra comportamentului acidului stearic (octadecanoic), supus unui fascicol de neutroni termici în câmp electric şi termic. A fost măsurată dependenţa curentului I de tensiunea U aplicată pe probă la creşterea şi descreşterea valorilor tensiunii şi la diverse temperaturi. Au fost efectuate studii de microscopie optică pe probe neiradiate, la diferite temperaturi; s-a evidenţiat efectul iradierii asupra probelor în starea mesomorfă. Se prezintă şi se analizează dependenţele I=I(U) la T=ct şi I=I(T) la U=ct şi în final se determină energia de activare.

In the paper, we present a study on the behavior of the stearic (octadecanoic) acid in a thermal and electric field, and subjected to a thermal neutron beam. The current I dependence on the voltage U applied to the sample was measured at increasing and decreasing voltage values and at different temperatures. Optical microscopy studies were carried out on non-irradiated samples, at different temperatures and have shown the effect of the irradiation on the samples, while in the mesomorphic state. Dependencies I=I (U) at T=ct. and I=I(T) at U=ct.are presented and analysed and finally the activation energy is determined.

Keywords: stearic acid, thermal neutron beam, thermal and electric field

1. Introduction

Recent research papers in biophysics and biochemistry highlight the profound implications that phenomena related to liquid crystals have in carrying out biological processes. One of the most interesting question related to the molecular biophysics is the problem of the cell membrane structure. Singer [1], [2] formulated the idea that cell membranes have a "mosaic" structure. Main cell membrane components are lipids and proteins. Different models for the

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membrane using certain experimental techniques have been proposed. A strategy frequently used in membrane physiology is the study of the isolated membrane components. An important information was obtained by studying the influence of various physical fields upon different natural constituents of biological membranes [3, 4, 5, 6].

2. Measuring Instruments and Materials

Stearic acid has been extracted from melted alloy and embedded in a transparent planar parallel electrodes system, with a distance of 24 μm between the electrodes. The system temperature has been measured using a Cu-Constantan thermocouple located inside the cell by connecting the thermocouple terminals to the X connector of an X-Y recorder.

The current-voltage dependency graphs have been plotted by positioning the liquid crystal cell in series with a variable 1MΩ÷10MΩ resistance, a high precision galvanometer and a DC source of IFA type. The voltage on the resistance terminals has been measured using a micro-voltmeter and the voltage on the liquid crystal cell has been determined from the Kirchhoff relations. The circuit current has been measured using the galvanometer settled in the series circuit.

The liquid crystal cell placed in the heating plant has simultaneously been observed in polarized light through an IOR-MC 1 microscope, which allowed tracking of microstructure issues corresponding to the studied mesophases interval.

For applying the neutron field, a Pu-Be source was used, with a fluence of $1.6 \cdot 10^3$ n/cm^{2}s. The source was placed in a graphite prism, of dimensions $(264.4 \times 214 \times 263.5\,\text{cm})$ with cylindrical channels (the distance between axes channels being 22.25 cm).

The neutron source was placed close to the prism axis, approximately 1 m from the top of the prism.

3. Experimental Aspects

We have studied the dependency of the electric current on the applied voltage on stearic acid samples irradiated for 48 hrs, in order to see the influence of a thermal neutron field on the samples comparing with nonirradiated samples. We have obtained the $I = I(U)$ dependencies at $T = 23$ ºC depicted in Fig.1 (a, c – nonirradiated samples), respectively Fig.1 (b, d – irradiated samples)

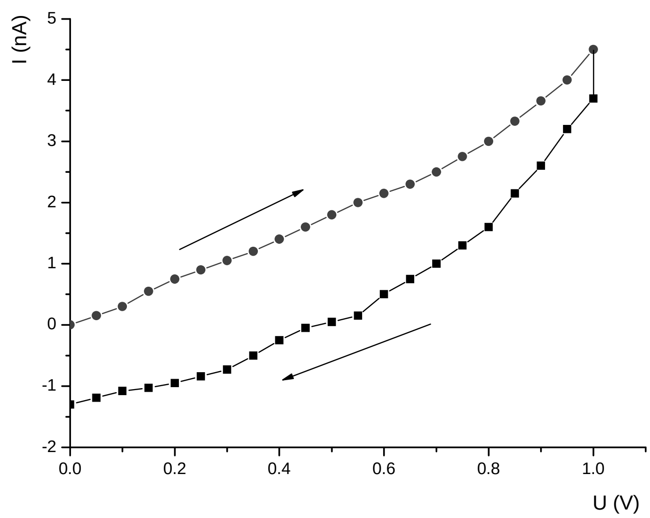


Fig. 1a. $I = I(U)$ dependence, nonirradiated sample (U_{max} = 1V)

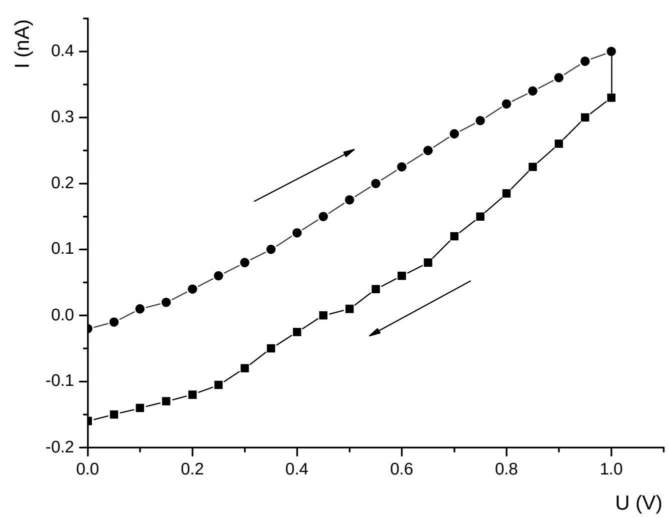


Fig.1b. $I = I(U)$ dependence, irradiated sample (U_{max} = 1V)

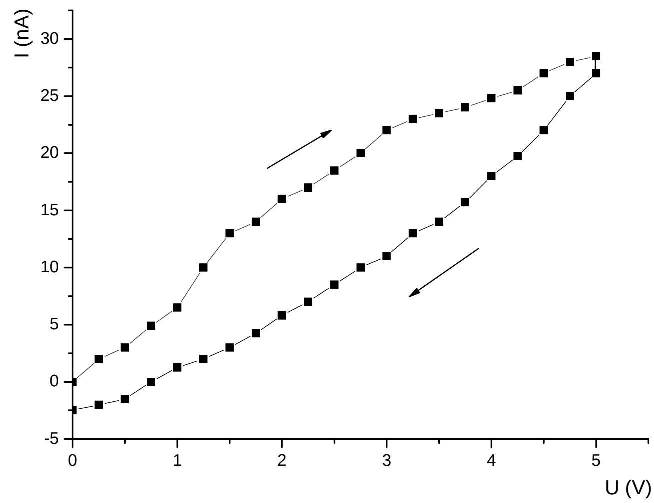


Fig.1c. $I = I(U)$ dependence, nonirradiated sample ($U_{max} = 5V$)

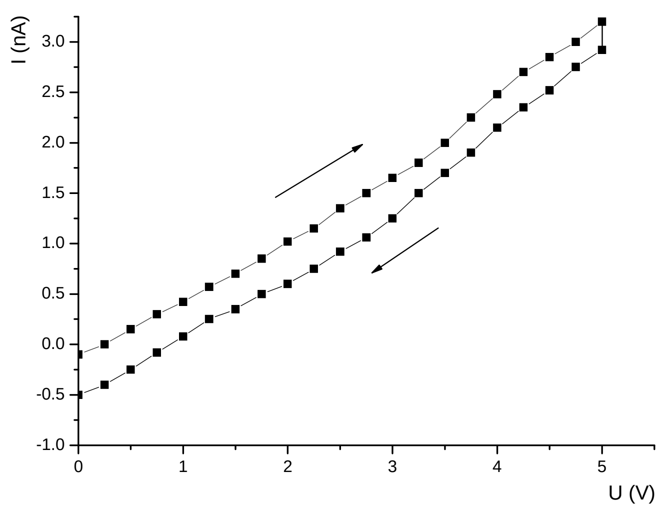


Fig. 1d. $I = I(U)$ dependence, irradiated sample ($U_{max} = 5V$)

We have also studied the current variation through nonirradiated and irradiated samples with increasing of the temperature and we have obtained the dependencies at $U = ct$. in Fig. 2 (a, b).

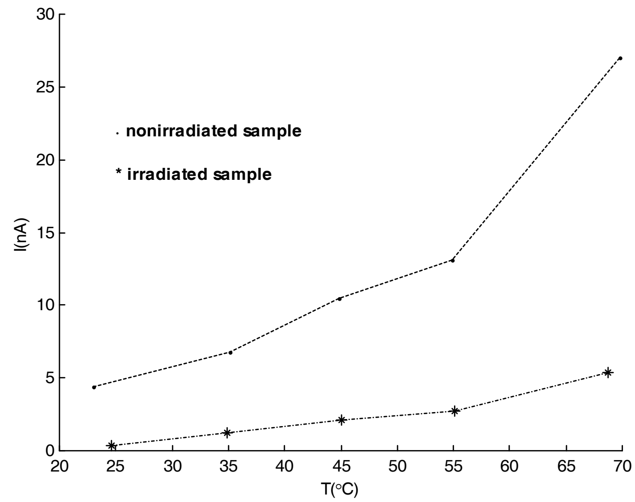


Fig. 2a. $I = I(T)$ dependence ($U = 1$V)

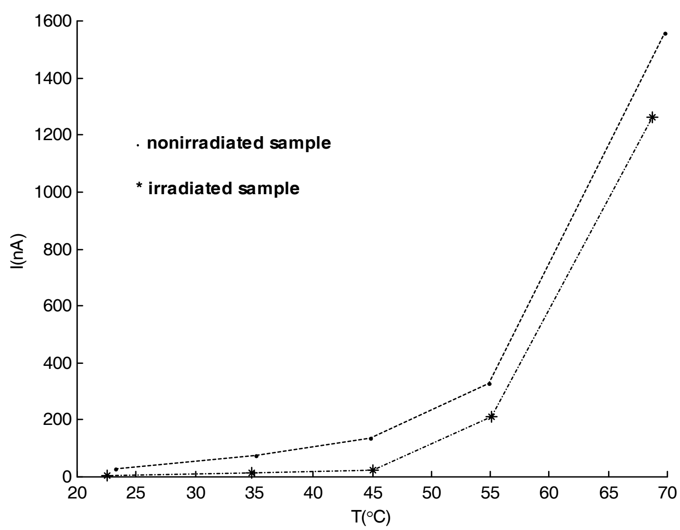
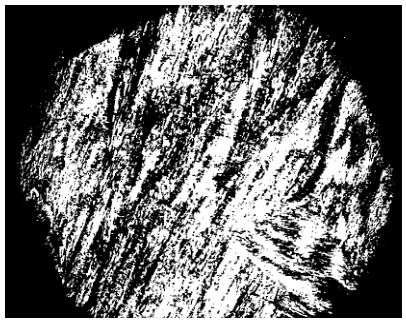
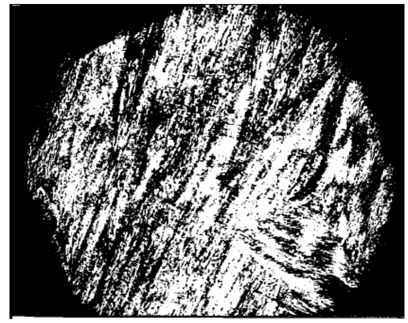


Fig. 2b. $I = I(T)$ dependence ($U = 5$V)

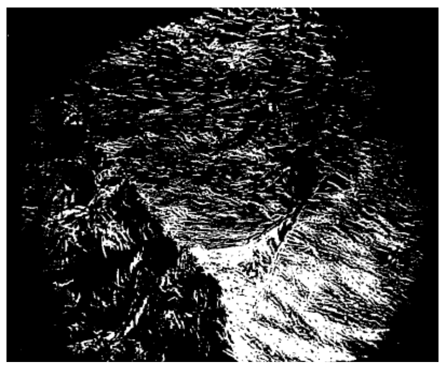
An adequate assembly allowed microstructure observations during measurements. The textures characteristic to the temperatures of 30ºC, 40ºC and 65ºC are shown in Fig. 3 (a, b, c).



a)



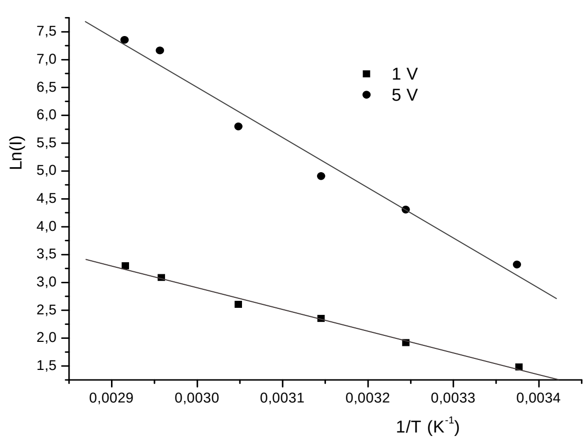
b)



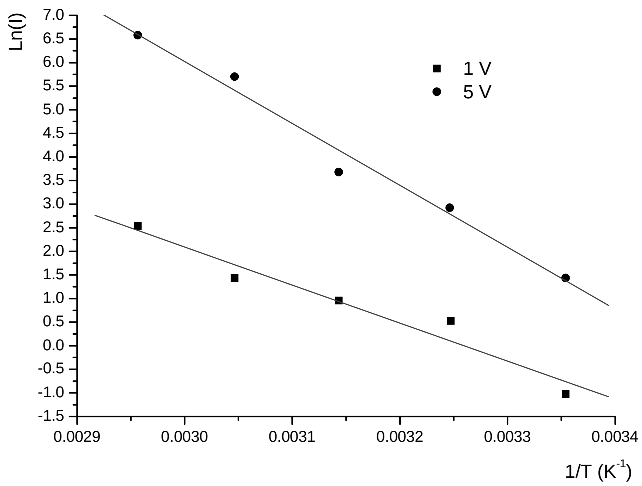
c)

Fig. 3. The microstructural aspect specific to the stearic acid at: a) 30ºC ; b) 40ºC ; c) 65 ºC

From the $\ln I = f\left(\frac{1}{T}\right)$ (Arrhenius-type) dependencies shown in Fig. 4 (a,b) we have determined the activation energies.



a)



b)

Fig. 4.
a) ln I = f(1/*T*) dependence at *U* = 1V and *U* = 5V (nonirradiated sample)
b) ln *I* = *f*(1/*T*) dependence at *U* = 1V and *U* = 5V (irradiated sample)

The following values of the activation energies were obtained:

nonirradiated samples		irradiated samples	
U	ΔE [eV]	*U*	ΔE [eV]
1V	0,335	1V	0,692
5V	0,775	5V	1,128

4. Conclusions

The phase transitions study correlated with the microstructure observations have shown a thermotrope enanthiotrope liquid crystal behavior for a 23ºC÷68,5ºC temperature interval and for the samples of 24 µm thickness.

When increasing the voltage through the sample within $\left(2\cdot 10^4\ \text{V/m} \div 2\cdot 10^5\ \text{V/m}\right)$ electric field interval, the electric current modifies with one order of magnitude in the case of non-irradiated samples, Fig. 1.(a, c) and also references [7, 8] and [9].

We have observed a remarkable change in the electric current-voltage dependencies for the samples irradiated with thermal neutrons, the electric current through the sample decreasing with one order of magnitude Fig. 1(b, d). Irradiated samples behavior has been explained by a thermodynamic model adjusted to take into account the stearic acid molecule deformation in the applied neutron field [8].

The current - temperature dependencies have shown an increase in the current intensity through the sample with the temperature increase (Fig. 2). The exponential dependency of the electric current through the sample with the temperature (Fig. 2), shows that at high temperatures, electrical charges are generated, leading to the current growth through the sample.

A remarkable change in the textures corresponding to different temperatures within the mesomorphism interval, Fig. 3, is observed.

Activation energies obtained from the dependencies in (Fig. 4), by using the slope of $\ln I = f(1/T)$, are in agreement with the stearic acid mesomorphism state.

The increasing of activation energies at irradiated samples as compared with the nonirradiated one can be explained by the apearing current due to the mechanical deformation of the molecules by action of the neutron beams.

Acknowledgements

The research is supported by CNMP grant No.91058/2007

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