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Physics

A COMBINED EFFECT OF ELECTROSTATIC FIELD AND HYDROSTATIC PRESSURE ON THE STABILITY OF BILAYER LIPID MEMBRANES

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The paper is devoted to the experimental research of bilayer lipid membranes stability (BLM) at joint action of an electrostatic field and hydrostatic pressure. It is shown, that with increase in a potential difference on BLM the average time of a life of a membrane decreases. Presence of hydrostatic pressure increasing leads to additional reduction of average time of the membrane life.

Keywords: BLM, lifetime, difference of potential, hydrostatic pressure.

The issue of cell membrane stability is central in membranology [1]. The extreme complexity of cell membranes urges to study this problem using a model, a bilayer lipid membrane (BLM). As known, the membrane is often impacted both by electric forces and hydrostatic pressure [2]. For this reason studying a combined effect of electrostatic field and hydrostatic pressure on BLM is of interest. This experiment is a based research focused on a combined effect of hydrostatic pressure and transmembrane potential difference on the BLM stability. As a parameter characterizing the level of stability of BLM, we assumed a lifetime of BLM at specified values of electrostatic field and hydrostatic pressure [3].

Research and results. The experiments were performed on BLM obtained from phosphatydiserine, earlier suspended in nonane. BLM was formed by the method of Muller et al. [4] on a hole with a 1 *mm* diameter in a PTFE (polytetrafluorethylene) cell. On the both sides of the membrane 0,1 *M* NaCl solution (pH=6,1) was positioned. All the experiments ran at 20^0C. The potential difference was applied to BLM by chlorine-silver electrodes, connected to ADT (NI USB-6008) and regulated by computer. The voltage varied between 150 and 350 mV with a pace 50 mV. Hydrostatic pressure was reached adding NaCl solution to one of two compartments of the cell. The BLM lifetime was determined applying a computer program.

In the first instance, in mean lifetime of BLM change was studied depending on the voltage increase in the absence of hydrostatic pressure (Fig., curve 1). As seen from Fig., the effect of electrostatic field brings to a drastic mean lifetime reduction. The loss of BLM stability in electric field is connected with formation of through hydrophilic pores [3, 5]. Pores in BLM arise spontaneously, and then as

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a result of a random change in size, reach some critical size, after which the BLM looses its stability. Mean lifetime of BLM exponentially reduces with an increase in transmembrane voltage [6, 7].

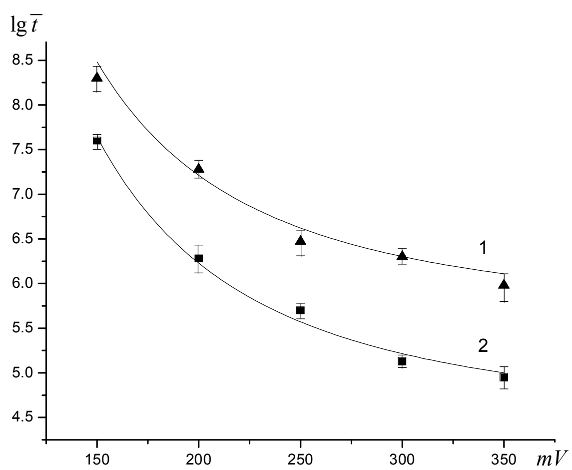
Then we studied the impact of the potential difference on the mean lifetime of BLM in the presence of given hydrostatic pressure p =12,64 *Pa* **(**Fig., curve 2). This figure demonstrates that dependence of mean lifetime of BLM on potential (curves 1 and 2) is similar. However, the second curve runs lower, which means that the mean lifetime of BLM reduces at hydrostatic pressure.

The loss of BLM stability under hydrostatic pressure can be predetermined by change either in BLM tension [8] or in the number of malformations on BLM [6]. To find out which of the two factors predetermines the loss of BLM stability, let's fit the experimental data with equations for the mean lifetime of BLM [6], employing a least-squares technique:

$$\ln \bar{t}(\varphi) = A + \frac{B}{1 + \dfrac{C\varphi^2}{2\sigma}}, \qquad (1)$$

$$A = \ln \frac{(kT)^{3/2}}{4\pi n D\gamma \left(\sigma + \dfrac{C\varphi^2}{2}\right)^{1/2}}, \qquad B = \frac{\pi\gamma^2}{\sigma kT},$$

where σ is the surface tension of BLM ($\sigma \simeq 2\cdot10^{-3}$ *N/m* [5]); γ is the linear tension of a pore edge in BLM; n is the number of malformations on the membrane; D is the coefficient of malformation diffusion in the radial space; φ is the difference of potential applied to membrane; k is the Boltzmann's constant; C is the reduced capacitance determined by a correlation $C = C_0(\varepsilon_w / \varepsilon_m - 1)$, where $C_0 = \varepsilon_0\varepsilon_m / h$ is the specific electric capacitance of the membrane; ε_w is the dielectric water transparency, and ε_m is the dielectric permeability of BLM.



Reduction of mean lifetime of BLM at increasing potential difference: 1 – in the absence of hydrostatic pressure difference on the membrane; 2 – in the presence of hydrostatic pressure p=12,64 *Pa*. Dots indicate experimental data, continuous line – theoretical curves, drawn according to equation (1) through a least-squares technique.

Collating theoretical lines with experimental points allowed determination of A and B parameters. As indicated above, in the both cases the values of B parameter practically coincide (B=2,50 on curve 1 and B=2,26 on curve 2), whereas A parameters differ by values (A=5,57 on curve 1, A=4,40 on curve 2). The analysis of equation (1) and its collation with data obtained for A and B indicates that reduction of mean lifetime of BLM in the presence of hydrostatic pressure cannot be connected with changes in surface (σ) or linear (γ) tensions. One can suppose that reduction of mean lifetime of BLM at hydrostatic pressure should be connected with the increase in the number of malformations (n) on BLM. It also proves that the difference of BLM hydrostatic pressure leads to the expansion of its area [4].

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Հ. Կ. Գևորգյան

Աշխատանքը նվիրված է երկշերտ լիպիդային թաղանթների (ԵԼԹ) կայունության փորձարարական ուսումնասիրությանը էլեկտրաստատիկ դաշտի և հիդրոստատիկ ճնշման համատեղ առկայության պայմաններում: Ցույց է տրվել, որ ԵԼԹ-ի վրա պոտենցիալների տարբերության աճի դեպքում թաղանթի կյանքի միջին տևողությունը կարճանում է: Հիդրոստատիկ ճնշման առկայությունը հանգեցնում է ԵԼԹ-ի կյանքի միջին տևողության լրացուցիչ կրճատման:

А. К. Геворгян.

Совместное действие электростатического поля и гидростатического давления на устойчивость бислойных липидных мембран

Работа посвящена экспериментальному исследованию устойчивости бислойной липидной мембраны (БЛМ) при совместном действии электростатического поля и гидростатического давления. Показано, что с увеличением разности потенциалов на БЛМ среднее время жизни мембраны уменьшается. Наличие гидростатического давления приводит к дополнительному уменьшению среднего времени жизни БЛМ.