22. *Хиженков П.К., Кузик А.В., Нецветов М.В., Добрица Н.В., Дрибан В.М.* Ионофоретическая активность низко- и сверхнизкочастотных электрических токов // Доповіді національної академії наук України. 2001. № 5. С. 165–167.
23. *Черний В.И., Назаренко В.Г. и др.* Нимодипин в лечении мозгового инсульта (методические рекомендации). Донецк, 2001.

Поступила 25.03.2002

Summary

The aim of this work is the blocking effect (for Ca^{++}) of an alternative magnetic fields (H_A) and electric current (I_A). In experiments on mousses utilising histological methods and the method of a spectrophotometery is shown, that the Ca^{++} at a calcium diet is stored in staggered hemisphere of mice. At application of H_A and (or) I_A of different frequency lowering accumulation of Ca and pinching of Mg. Optimal frequencies of magnetic fields are 8, 16, 24, 50 Hz of H_A and 16, 24, 50 Hz of I_A.

B.S. Philipp, O.V. Yaltycenko

HEMOGLOBINE OXYGENATION PROCESS IN AN EXTERNAL ELECTROMAGNETIC FIELD

Institute of Applied Physics, Academy of Sciences of Moldova,
Academic str. 5, MD-2028, Kishinev, Republic of Moldova

The influence of the external laser electromagnetic field on the hemoglobine molecule is for a great theoretical interest and seems to be important for the application [1–4]. It is known, that hemoglobine (hem) molecule in nonoxidized (*dh*) form has nonzero dipole moment, so called dezoxy hem (*dh*). This dipole moment appears due to the pseudo Jahn-Teller' effect [5]. As distinguished from the oxy-form (*oh*) in the *dh*-form, the existence of the constant electronic dipole moment leads to an active interaction between *dh*-molecule with the external electromagnetic field.

The interaction of the electronic dipole moment of the *dh*-molecule with the electric component of the laser field provides new ways for the oxidation process in hemoglobine. At the absence of the electromagnetic field the hemoglobine oxidation process is described by the known Perutz' model [6] (the *dh*-form differs from the *oh*-form because the iron ion goes out from plane of the porphyrine's ring). It is important to remark that the vibration A_{2u} is connected with the motion iron ion and mix a_{1g} and a_{2u} electronic molecular orbitals of D_{4h} group symmetry the (energy gap is about 1 eV for *dh*-form, and 3 eV for *oh*-form).

For dezoxy hemoglobine the pseudo Jahn-Teller' effect leads to the narrowing of upper adiabatic potential and softening the lower adiabatic potential, so that the harmonic approximation is broken and two minima on lower sheet of the adiabatic surface appears (see fig.1).

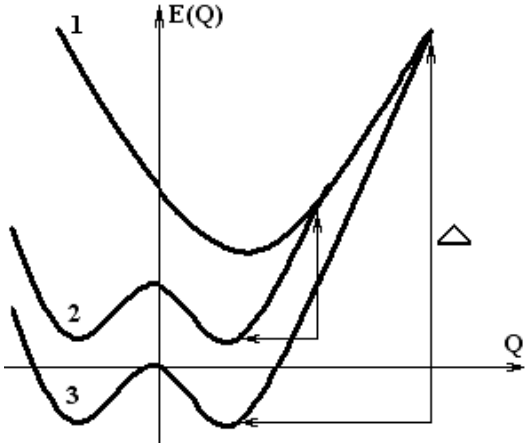

Fig. 1. Adiabatic potentials oxy- and dezoxy-form hemoglobine (curve 1 and 3), 2 – foton satellite curve 3.

The explicit form of the adiabatic potential is the following:

$$E_{\pm}=\frac{1}{2}\omega^2Q^2 \pm(\delta^2+V^2Q^2)^{1/2}, \quad (1)$$

where δ – energy gap between the electronic levels, V is coefficient function of the electron – vibrational interaction, ω is vibrational frequency, corresponding to the reaction coordinate.

It's known that the pseudo Jahn-Teller' effect is not important for the *oh* hem. Application of the external electromagnetic field provides a new channel of hem oxidation. For the oxidation process of the hem molecule in the presence of the external electromagnetic field it is important to analyze the optical transition from the ground state of the *dh* to the exited state of the oh and with the relaxation to the ground state of *oh.*

The full oxidation process is described by

$$W = W_L+W_D, \quad (2)$$

here W_D is the transition probability of oxidation process, without light (dark-process) and W_L is the probability of oxidation process, which induced by the laser field. The explicit expressions for the probability transitions W_D and W_L depend on the energy barriers, frequencies factors, and transmission coefficient. The expression for W_D in a simple form may be presented due to the transmission coefficient from the ground state of *dh* to the ground state of *oh* in the Perutz' model:

$$W_D = \omega\kappa_p e^{-\Delta/kT}, \quad (3)$$

where κ_p is the transmission coefficient with energy activation Δ, here Δ is the energy gap between *oh* and *dh* forms (Δ ≈ 2 eV [5]), T is the temperature, k – Boltzman' constant.

The value W_L is proportional to W_L^0 – the transition probability from the photon-satellite (one photon excitation corresponding to the ground electronic term) of the *dh* to the exited state of *oh*. The transition probability from the exited state to ground one of *oh* is large enough, so it is important to calculate only W_L^0. The formula for W_L^0 has the same form as W_D:

$$W_L^0 = \Omega\kappa_L J_1^2(\rho)e^{-\Delta_2/kT};\ \Delta_2 = \Delta - \hbar\Omega, \quad (4)$$

where κ_L is the transmission coefficient between photon satellite of the *dh* and excited state of *oh* molecules, $\hbar$ is the Plank' constant.

For the He-Ne-laser ($h\Omega$ = 1.9 eV), kT = 0,03 eV, power (1÷10) mW/cm^2 we find:

$$W_L/W_D = 10^3\,\kappa_L\Omega/(\kappa_p\omega)J_1^2(\rho). \quad (5)$$

The frequency of reaction coordinate $\omega = 10^{13}c^{-1}$ the transmission coefficient in the exited state is larger in comparison with the transmission coefficient κ_p (due to large overlap of the wave function so the optical induced oxidation of hem may be larger than dark-process in Perutz' scheme).

We hope this fact is in the ground of the useful action of the laser radiation on the human blood. The wide using of the low intensity laser radiation for therapeutic purposes, including the intravenous blood radiation, raises the interest to investigate the possible mechanism of optical radiation interaction with blood components.

The influence of visible light (640±10 nm) and He-Ne laser radiation (633nm) on the hemoglobine solution of on the oxygenation process of the human hemoglobine was investigated. Nonstabilized venous blood in phosphate buffer (1/15M, pH 7,8) was used. The light irradiation was performed in glass cups in 3mm thickness layer at the power density of 7,0 mW/cm^2 during 5 minutes. The optical density measurements were carried out at oxyhemoglobine absorption maximum (577 nm). The oxygenation was made at room temperature (20ºC) in the dark in open cups.

It has been shown that the five minutes' radiation results in two-fold increase the optical density of the hemoglobine solution in oxyhemoglobine absorption maximum (fig. 2).

The effect is practically the same for both types of optical radiation. It's known that the absorption spectra changes of protein molecules including hemoglobine are related to conformational rearrangements in

certain parts of molecules. The conformational changes in hemoglobine molecules and those related to optical parameters occur when the binding and decoupling of oxygen molecules take place.

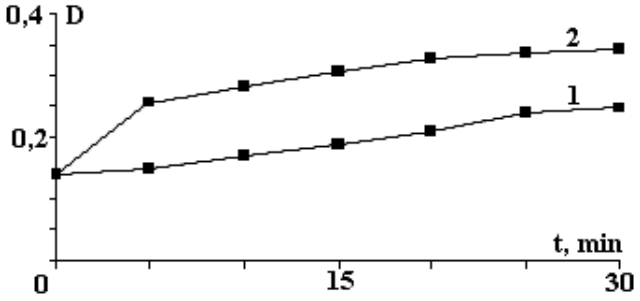

Fig. 2. Time dependence optical density D
(curves 1 – dark process; 2 – process including electromagnetic field).

Our results give the evidence in favor of photoconformational changes in hemoglobine molecules, which may positively influence on the efficiency of oxygen binding in the hemoglobine.

This investigation is supported by INTAS grant № 99-01495.

REFERENCES

1. *Kovarsky V.A., Yaltychenko O.V., Filipp B.S.* Vth – The Jahn-Teller International Symposium. Boston. Proc. 2000.
2. *Kovarsky V.A., Philipp B.S.* World Congress on Medical Physics and Biomedical Engineering, Nice, France, September 14–19. 1997.
3. *Тарасьев М.Ю., Рыльков В.В.* Фотопревращения форм гемоглобина в буферных растворах // Биохимия. 1991. Т. 56. № 2. С. 273–280.
4. *Летохов В.С.* Лазерная пикосекундная спектроскопия и фотохимия биомолекул. М., 1987.
5. *Bersuker I.B.* The Jahn – Teller Effect and Vibronic Interaction in Modern Chemistry; M., 1987.
6. *Volkenstein M.V.* Molecular Biophysics. M., 1975.

Received 18.05.2002

Summary

The dipole moment due to the pseudo Jahn-Teller' effect in the dezoxyform of hemoglobine is analyzed. The interaction between this dipole moment and external laser electromagnetic field is taken into account. It is shown, that the first photon satellite provides the quantum transition into the exited electronic state of the oxyhemoglobine molecule. This is the new way of the hemoglobine oxygenation process and probably is in the base of the useful action of the laser radiation on the blood.