Installation for growing protein crystals under terrestrial and space conditions with active crystallization process control

© I.Zh. Bezbakh[1], I.N. Radchenko[1], B.G. Zakharov[2], V.I. Strelov [2]

[1]Kaluga Branch of Bauman Moscow State Technical University, Kaluga, 248000, Russia
[2]"Space Materials" Research Center of the Shubnikov Institute of Crystallography, Russian Academy of Sciences, Kaluga, 248640, Russia

Crystallization of biomaterials is necessary in biology and medicine for determination of spatial structures of organic molecules by crystallographic methods that further allows to carry out the synthesis of new substances having the desired properties, and to solve some fundamental problems of functioning live systems in general. One of the major factors determining success of this research is the processes of biocrystal growth implemented not only during earth-based experiments, but also in space. A method of temperature controlling protein crystallization processes is much more technologically advanced and more effective for growing highly perfect crystals in comparison with traditional methods. In this method convection in the solution is excluded, and the influence of vibration on the crystallization process is virtually eliminated. This way in terrestrial conditions the best possible approximation to the diffusion conditions of heat and mass transfer in the protein solution is ensured, and in the space environment the diffusion mode is achieved, i.e., conditions of protein macromolecule self-organization are provided during their embedding into a crystal lattice. Thus the process of macromolecule crystallization becomes controllable and reproducible. Based on the analysis performed it has been concluded that the automated equipment with temperature controlling processes of nucleation and crystallization of proteins, as the most effective for highly perfect protein crystals, should be created. On the basis of developed simple in design and low-mass-dimensional crystallization apparatus a series of experiments on the successful growth of high-quality protein crystals of lysozyme has been carried out.

Keywords: *protein, crystal, growth, control, mathematical modeling*

REFERENCES

[1] Kuranova I.P. *Poverkhnost. Rentgenovskie, sinkhrotronnye i neitronnye issledovaniya. – Surface. X-Ray, Synchrotron and Neutron Research*, 2004, no. 6, pp. 4–12.

[2] Chayen N.E. *Current Opinion in Structural Biology*, 2004, vol. 14, pp. 577–583.

[3] Bezbakh I.Zh., Kosushkin V.G., Zakharov B.G., Strelov V.I., Artemyev V.K., Ginkin V.P. Folomeev V.I. Optimizatsiya rosta kristallov belkov s primeneniem metoda teplovogo upravleniya [Optimization of protein crystal growth using the thermal control method]. In: *Metody issledovaniya i proektirovaniya slozhnykh tekhnicheskikh system: Sbornik statey (Trudy BMSTU no. 592)* [Methods of Complex Technical Systems Research and Design. Collection of articles (Proceedings of BMSTU no. 592)]. Moscow, BMSTU Publ., 2006, pp. 18–26.

[4] Rosenberger F., Howard S.B., Sowers J.W., Nyce T.A. *Journal of Crystal Growth*, 1993, vol. 129, pp. 1–12.

[5] Luft J.R., Rak D.M., De Titta G.T. *Journal of Crystal Growth*, 1999, vol. 196, pp. 447–449.
[6] Strelov V.I., Zakharov B.G., Bezbakh I.Zh., Sosfenov N.I. *Kristallografiya – Crystallography*, 2008, vol. 53, no. 1, pp. 145–148.
[7] Bezbakh I.Zh., Strelov V.I., Zakharov B.G. Rentgenodifraktsyonnaya kharakterizatsiya kristallov belkov, vyraschennykh metodom upravleniya temperaturoy [X-ray diffraction characterization of protein crystals grown by temperature control]. In: *Sovremennye metody analiza difraktsionnykh dannykh i aktualnye problemy rentgenovskoy optici: Materialy VI-go mezhdunarodnogo nauchnogo seminara, 19-27 avgusta 2013 g.* [Modern methods of diffraction data analysis and actual problems of X-ray optics: Proceedings of the International Scientific Workshop, August 19–27 августа 2013]. Velikiy Novgorod, N. Branch of St. Pet. SEU Publ., 2013, pp. 206–208.

Bezbakh I.Zh. (b.1978) graduated from Kaluga Branch of Bauman Moscow State Technical University. Ph.D., assoc. professor of the Physics Department at Kaluga Branch of BMSTU. The author of more than 20 works on methods and the equipment for crystal growth (semiconductors, crystals of biological materials). e-mail: biz001@mail.ru

Radchenko I.N. (b. 1961) graduated from the Leningrad polytechnic institute named after M. I. Kalinin. Ph.D., assoc. professor of the Physics Department at Kaluga Branch of Bauman Moscow State Technical University. The author of more than 40 scientific works in physical electronics and solid state physics. e-mail: rin-kf@yandex.ru

Zakharov B.G. (b. 1937) graduated from the Leningrad state university named after A.A. Zhdanov. Dr. Sci.(Eng.), senior staff scientist at the Branch of Shubnikov Institute of Crystallography of the Russian Academy of Sciences, "Space Materials" Research Center. The author of more than 200 scientific works in crystal growth and solid state physics. e-mail: zakharov@kaluga.rosmail.com

Strelov V. I. (b. 1952) graduated from the Moscow Institute of Electronic Technology. Dr. Sci. (Phys.&Math.), director of the Branch of Shubnikov Institute of Crystallography of the Russian Academy of Sciences, "Space Materials" Research Center. The author of more than 150 scientific works in crystal growth and solid state physics. e-mail: strelovvi@kaluga.ru