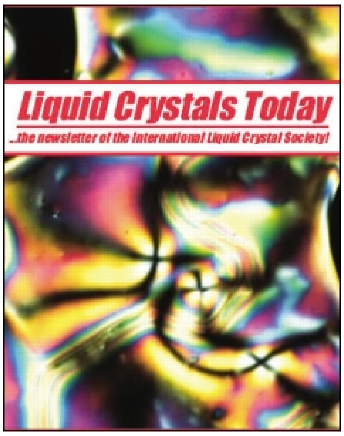

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Freedericksz Medal for Professor Yu.M. Yevdokimov

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REPORT

Freedericksz Medal for Professor Yu.M. Yevdokimov

The scientific interests of Yuri Yevdokimov (YuYe) are connected with the investigation of the liquid-crystalline state of nucleic acid molecules *in vitro* and *in vivo*.

The proof of the existence of multiple forms (such as two types of cholesterics with left- or right-handed twist of spatial structure as well as nematic in particles of liquid-crystalline dispersions formed by double-stranded nucleic acids) is an important contribution of YuYe in the physical chemistry of liquid-crystalline polymers. *A priori* existence of different structural forms, easily realised in particles of liquid-crystalline dispersions, was impossible to predict unequivocally due to a so-called 'size effect'. For the first time, YuYe has shown that depending on the secondary structure of nucleic acids, on their nitrogen base content, on ionic content or the temperature of the solvents used for the phase exclusion of double-stranded nucleic acids, one can realise the formation of various modes of packing of these molecules in particles of dispersions. Besides, various low- and high-molecular mass biologically active compounds (antibiotics, polypeptides, polysaccharides, etc.), interacting with nitrogen bases of nucleic acids, represent themselves as powerful regulators of the character of the spatial packing of nucleic acid molecules in particles of liquid-crystalline dispersions. This work has been awarded with the Prize from the Presidium of Academy of Sciences of the USSR and the Presidium of Academy of Sciences of the German Democratic Republic.

YuYe's scientific contribution to the development of theoretical backgrounds for the formation of liquid-crystalline dispersions of nucleic acids and their complexes with chemically and biologically relevant compounds, and the experimental methods of studying their properties has been recognised at an international level; this contribution was emphasised by that fact that the leading journal in the area of liquid crystals, *Liquid Crystals*, in 1988, 1992 and 2003 invited him to publish reviews on various aspects of research about the liquid-crystalline state of nucleic acids.

Being based on the developed theoretical and experimental background, YuYe, for the first time, has formulated ideas concerning the potential for the application of particles of liquid-crystalline dispersions of double-stranded nucleic acids as microscopic size, multifunctional, sensing elements (biosensing units), i.e. ideas about the possibility for the creation of new types of bioanalytical devices in which the sensing elements are double-stranded nucleic acids. YuYe and his team have developed various types of liquid-crystalline biosensing units for the determination of biologically active substances interacting with nucleic acids and their complexes. The creation of these portable bioanalytical systems for detection of biologically active substances earned YuYe, together with the Institute of Spectroscopy of the Russian Academy of Sciences, a Gold Medal at the 50th International Exhibition of Innovations, Researches and New Technologies 'Eureka' (Brussels) and also a Grand-Prix in the Russian Innovation Competition.

Since 1996 YuYe and his Russian and foreign colleagues and pupils, in parallel with research into the properties of DNA liquid-crystalline dispersions, have started to develop a novel strategy of 'nanodesign', i.e. a strategy for the creation of structures in which the molecules of biopolymers spatially ordered in particles of their liquid-crystalline dispersions represent 'building blocks' that can be linked by 'nanobridges'. Taking into account the fact that the study of the physicochemical properties of particles of nucleic acid liquid-crystalline dispersions resulted in detailed information about the conditions required for the formation of particles of cholesteric liquid-crystalline dispersions (CLCD), and the factors providing for their control, the main problem to be solved could be formulated as follows: to link neighbouring DNA molecules in quasi-nematic layers of cholesteric liquid-crystalline particles so that the spatial ordering pattern in these particles does not change.

And this problem had now been solved. Spatial structures with tailored physical and chemical properties, formed by means of this strategy, have received the name 'nanoconstructions based on biopolymers'. It has been demonstrated that the nanobridges composed of alternating molecules of the anti-tumour anthracycline antibiotic daunomycin (DAU) and copper ions link the DNA molecules located both in the same and neighbouring quasi-nematic layers

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of liquid-crystalline particles. The elegant strategy that was suggested and practically realized for the creation of nanoconstructions based on particles of DNA cholesteric liquid-crystalline dispersions differs from known strategies of the creation of nanostructures used by other authors. By this strategy, nanoconstructions were obtained, the existence of which was impossible to predict beforehand. The formed nanoconstructions possess unique properties. First, for instance, unlike the initial CLCD particles, the main factor stabilizing the nanoconstructions is the number and 'strength' of the nanobridges rather than the osmotic pressure of the water-salt polymer-containing solutions. Second, the liquid packing mode of the neighbouring DNA molecules in the nanoconstructions and the DNA diffusion mobility disappeared; the structure became 'rigid' and the particles acquired the properties of a solid material. Third, a characteristic of the DNA nanoconstruction is not only an abnormal optical activity, which appears as an intense band in the circular dichroism (CD) spectra in the DNA absorption region, but also an additional abnormal optical activity in the absorption region of DAU chromophores. Finally, the nanoconstructions not only retain a high local concentration of DNA molecules (reaching 400 mg/ml), but also acquire a high concentration of DAU. The most important fact is that the potential for the transition from a 'liquid' state of particles of DNA cholesteric liquid-crystalline dispersions into a 'rigid' state was realized for the first time. Rigid DNA nanoconstructions permit their easy immobilization on the surface of nuclear filters and manipulation with these particles (for instance, cutting nanoconstructions and their spatial translocation). The whole set of unique physical and chemical properties of rigid DNA nanoconstructions has opened a way for their wide application in various areas of science and technology (starting with a new type of biosensing unit for carriers of genetic material or various biologically active compounds and chemical substances introduced into these nanoconstructions).

For these studies in the area of the DNA nanotechnology based on the use of DNA molecules fixed in the structure of cholesteric liquid-crystalline dispersions YuYe received the Freedericksz Medal of the International Liquid Crystal Society in 2008 (for 'the outstanding contribution to chemistry of liquid crystals').

Professor Yu.M. Yevdokimov's presentation with the Freedericksz medal during the Ivanovo International Conference on Lyotropic Liquid Crystals, 2009. Here, Professor N.V. Usoltseva (left) of Ivanovo State University, Professor Yu.M. Yevdokimov (centre) and Professor S.A. Pikin (right) of the Institute of Crystallography of the Russian Academy of Sciences are shown.

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