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ACTUALITY OF COLLOID CHEMISTRY IN CHEMICAL EDUCATION OF STUDENTS OF MEDICAL AND PHARMACEUTICAL FACULTY

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Abstract

The article is dedicated to the one of the modern medical chemistry section named colloidal chemistry. It is not only component of basic chemical equation of future doctors and pharmacist, subject of medical and pharmacephtical scientific and experiment investigations but colloidal chemistry is the base of a modern and more promising direction of medicine called nanomedicine.

Key words: colloid chemistry; dispersed systems; nanoparticles; nanomedicine; QSAR-QSPR models.

АКТУАЛЬНІСТЬ КОЛОЇДНОЇ ХІМІЇ У ХІМІЧНІЇ ОСВІТІ СТУДЕНТІВ МЕДИЧНОГО ТА ФАРМАЦЕВТИЧНОГО ФАКУЛЬТЕТІВ

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Стаття присвячується одному з розділів сучасної медичної хімії – колоїдної хімії, яка є не лише складовою частиною базової хімічної освіти майбутніх лікарів і провізорів, напрямком наукових і експериментальних досліджень в медицині та фармації, але стає основою найбільш перспективного напряму медицини – наномедицині.

Ключові слова: колоїдна хімія, високодисперсні системи, наночастки, наномедицина, QSAR - QSPR моделювання.

Relevance

The formation of clinical thinking of future physicians and pharmacists is the result of mastering courses of bioinorganic, analytical, physical and colloidal chemistry in combination with knowledge of other natural disciplines, general-theoretical and special.

Disperse systems are widespread in biological objects from a single cell to a heterogeneous system of higher order – tissue. Blood, protoplasm, muscle and nerve cells, biomembranes, fibers, genes, and viruses have colloidal nature. The basis of nutrition, growth and development of living organisms are colloidal chemical processes. Knowledge of the properties and features of colloid-disperse systems is a prerequisite for understanding the very complex processes of vital activity of organisms; it creates conditions for medical diagnostics of pathological states by evaluating the stability of bioliquids according to polarization microscopy, data etc.

It is known that heterogeneity is the characteristic feature of disperse systems. The presence of the interfacial interface determines a special role of surface phenomena in disperse systems characteristic. The change in the specific surface of $1m^3$ of the substance under the condition of dispersing its particles to colloidal degree of dispersion (10^7-$10^9 m^{-1}$) is equal to ($6 \cdot 10^{-7} – 6 \cdot 10^{-9}$) m^2. Such a large surface causes a considerable supply of free surface energy $G_{s.}$ It is known from the thermodynamics section [1] that processes leading to a decrease in the Gibbs free energy stock ($\Delta G_s < 0$) occur independently. Therefore, colloidal systems with a large reserve of surface energy are characterized only by relative aggregative stability; they tend to aggregate particles of the dispersed phase, which provides a decrease in the interphase surface.

The object of colloidal chemistry is to study the properties of substances in a highly dispersed state and surface phenomena in disperse systems. The founder of colloid chemistry is English scientist T. Graham, who in the 60's of the XIX century divided all the substances into crystalloids and colloids. Fundamentals of colloidal chemistry originated in the XVIII – XIX centuries in the works of M.V. Lomonosov, F. Reiss, J. Berzelius, M. Faraday.

Colloidal chemistry and its scientific directions

Modern colloidal chemistry is a science of dispersed systems and surface phenomena. The objects of study of colloid chemistry are also one-dimensional-disperse systems (thin films), and two-dimensional-dispersed (thin threads). One of the main tasks of colloidal chemistry is the study of the influence of dispersion on the structure and properties of both individual particles and the system as a whole.

Previously molecules of globulin proteins were considered as perfectly monodisperse systems; in recent years, methods have been developed for the synthesis of such objects as fullerenes and dendrimers, which, when dissolved in a suitable solvent, provide systems that may well be regarded as perfectly monodispersed colloidal systems [2-3].

The growth of the dispersion of the system leads to an increase in the role of surface phenomena and surface forces, which leads to a significant change in the properties of disperse systems. At the same time, it is possible to separate the coarse and highly dispersed systems by two approximately coincident characteristics (in the earth's conditions and for the human eye): occurrence of sedimentation-diffusion equilibrium when reducing the size of the particles and the appearance of special optical properties in the visible range of wavelengths. Approximately the same particle size corresponds to the transition to the Relay scattering of light that is typical for colloidal systems. It should be borne in mind that in rude-dispersed systems with high content of the dispersed phase, for example in foams and concentrated emulsions, there are nanoobjects. They are thin films separating the cells of the dispersed phase, and the properties of thin films determine the stability of these systems [4]. Further growth of dispersion corresponds to the transition to systems that can be considered as colloidal, ultramicroheterogeneous, ultradispersed or nanosystems [5]. First and foremost, it is typical for them that a significant proportion of the substance of the dispersed phase (from the percents to tens of percents) is at the interface and the size of the particles becomes commensurate with the thickness of the surface layer, and in the presence of the electrolytes in the dispersion medium with the thickness of the diffuse part of the double electric layer. It is clear that in these conditions, the surface phenomena themselves become dominant in the properties of disperse systems. On the other hand, in the case of metal particles, there are features of absorption and scattering of light, which leads to a change in the color of metal sols depending on the size of the particles in them. Thus, the aurum sol changes its color from violet-blue to red, green, and yellow with increasing dispersion.

Colloidal chemistry and nanomedicine

According to the recommendation of the 7th International Conference on Nanotechnologies (Wiesbaden, 2004), the following types of nanomaterials are identified: nanoporous structures, nanoparticles, nanotubes and nanofibers, nanodispersions (colloids), nanostructured surfaces and films, nanocrystals and nanoclusters. As components of nanomaterials can be considered inorganic compounds (metals, carbon derivatives, etc.) and organic compounds, including natural ones (proteins, fatty acids, nucleic acids). The latter are one of the sections of nanotechnology called nanobiotechnology or biomolecular nanotechnology. Medical supplements of nanotechnologies have contributed to the emergence of a new scientific direction – nanomedicine. It covers such areas as tracking, correcting, constructing, and controlling human biological systems at the molecular level with the help of developed nanoparticles and nanomaterials that enable to perform operations ranging from diagnosis and monitoring to the destruction of pathogenic microorganisms, the restoration of damaged organs, and the supply of essential substances to the body. So far, such an interdisciplinary direction of medical science exists as projects only, although most experts believe that the proposed methods will become publicly available within this century. For example, the American National Institute of Health has included nanomedicine in the top five priority areas for the development of future medicine.

The capabilities of nanotechnologies and materials on their basis extend to the field of pharmaceutical chemistry as the creation of nanoparticles (micronization) of already known in medical practice substances [4-6]. There are countless technological methods for such a shredding of substances. Their result is obtaining suitable nanocrystals and nanosensors. Nanocrystals have some advantages over other modified forms of the substance: 1) high concentration (up to 100%) of the drug in the medical form; 2) the dissolution rate is predicted, which depends only on the structure of the nanomaterial; 3) simplicity and availability of production. Substances created in the form of nanosuspensions are successfully used to regulate the bioavailability of drugs such as amphotericin B, danazol, and tacrolimus.

This form of substance allows to regulate the dose of drugs and their pharmacokinetic profile [6].

Determination of the relationship between the structure of chemical bubstances and their properties is of the greatest interest. This question can be solved by studying and comparing their structure. The Department of Medical Chemistry, of Odessa National Medical university, has been conducting QSAR / QSPR scientific research with the National Academy of Sciences Physico-Chemical Institute named after O.V. Bogatsky for many years. Nano-QSAR simulation is a modern and effective tool for studying the connection between the structure and properties of the various *nanoparticles*. The results of the work on developing 1D descriptors for some inorganic compounds were presented in a report at the XV International Conference on Nanosciences and Nanotechnologies (NN18), 3-6 / 07-2018, held in Thessaloniki, Greece [7].

The effectiveness of the proposed approach was demonstrated by examining the cytoplasmotoxicity of 17 oxides of metals (ZnO, CuO, V_2O_3, Y_2O_3, Bi_2O_3, In_2O_3, Sb_2O_3, Al_2O_3, Fe_2O_3, SiO_2, ZrO_2, SnO_2, TiO_2, CoO, NiO, Cr_2O_3, La_2O_3 for E- coli and NAC cells).

In addition to developing (designing) innovative medicines, using different approaches to medical chemistry in the field of pharmaceutical chemistry, great importance is given to increasing the effectiveness of already known drugs. This is achieved through the creation of so-called prodrugs and the use of auxiliary substances in the form of a medicinal form that dramatically changes the physical and chemical properties of the pharmaceutical active ingredient (substance). This implies the creation of the ways (systems) for delivering the drug to the body by purpose.

Methods of teaching colloid chemistry at the medical and pharmaceutical faculty.

Physical chemistry of surface phenomena, properties of colloidal systems, aerosols and powders, suspensions and emulsions, surfactants and macromolecular compounds occupy a special place in the course of physical and colloidal chemistry for the students of the pharmaceutical faculty of the medical university.

Studying the course of colloid chemistry will allow the future specialist to master a certain minimum of knowledge in the field of manufacturing, quality control and storage of drugs, as well as their biotransformation in the human body.

At the Pharmaceutical Faculty students are studying methods for obtaining and purifying disperse systems, among which dialysis can be identified. This method of cleaning disperse systems underlies the operation of the artificial kidney apparatus. Molecular-kinetic, optical and electrical properties of disperse systems are studied in laboratory classes:

"Dispersion analysis of suspensions by sedimentation method", "Determination of the size of emulsion particles by the method of nephelometry".

Particular attention is paid to the problem of the stability of colloidal systems, the influence of the nature of the electrolytes and their coagulating effect. Determination of optimal coagulant in the proposed system can be used in the allotment of biologically active substances from plant material and in the study of the influence of various factors on the stability of biologically active substances [8].

Conclusions

The analysis of literary data shows the huge achievements in the field of colloid chemistry. It helps to investigate and establish a different functional relationship between the dispersion and properties of colloidal (including nano) systems. It explains the effect of particle size on the course of the process and gives the opportunity to develop optimal conditions for obtaining and stability of highly dispersed systems. The relationship between QSAR / QSPR for the study of the biological activity of various nanosystems is estabilished.

Such a research plan is promising in chemistry, biology and medicine in the study of colloid-chemical patterns: chemical and biochemical transformation of substances; receipts, distribution of substances in an organism, their metabolism; allotment of biologically active substances from natural sources and products of technological synthesis; study of the factors of stability and terms of suitability of medicinal products.

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