INNOVATIONS IN FUNDAMENTAL STUDIES FOR EDUCATION

Bagdaulet Kenzhaliev, Doctor of Technical Sciences
Bolysbek Utelbayev, Doctor of Chemistry
Essen Suleimenov, Doctor of Technical Sciences
Kazakh-British Technical University , Kazakhstan

Abstract

This article reviews the influence of new knowledge in natural sciences as it relates to development of innovative technical solutions. It explains the necessity of applying new scientifical concepts to the structure of liquid systems in educating versatile specialists in order to overcome difficulties in creation of effective technical solutions.

Keywords: New knowledge, fundamental studies, education

Introduction

Unprecedented technological progress - such as development of information technologies, introduction of nanotechnologies to the field of production of various materials with predetermined functional properties – causes need for continuous use of published results of modern fundamental studies in training of experts in chemical and metallurgical industry. Training of highly intellectual experts capable of creating waste-free technologies and carrying out their scientific and technical follow-up is commanded by the following issues: (1) escalating complexity of raw materials; (2) need for reducing energy cost per item produced; (3) need for eliminating redundant technological links in the raw material - finished product chain; and (4) urgent need of environment protection. In order to achieve high quality and low-cost production of competitive goods and development of innovative technologies, the specialists no longer can work without use of new data from natural sciences studies. It is necessary to develop skills for the fastest use of scientific innovations for practical use. Technical progress caused the growth of number of higher educational institutions in the world and, respectively, the growth of number of university-educated experts. These experts are to ensure the growing demand in various industries, and this resulted in need to tailor the process of training of specialists to new conditions. The most striking example of such urge is establishment of scientific and educational complexes (centers), research universities and super-universities across various countries. These organizations are mostly engaged in educating and upholding scientific research of various level of complexity in the course of training of experts, and they provide scientific and intellectual capacity of educational institutions to solve scientifically - applied tasks. However, this positive aspect of expert training has also a negative side. Carrying out experiments in interests of applied tasks, need to analyze a huge amount of the published material and conclusions from numerous experimental data create illusion of scientific progress. Thus, many unresolved issues in Natural Sciences studies are ignored and experimental results, which can't be explained from the existing scientific positions, are lost forever. Too many things are attributed to "an experiment error", "poor equipment" and "accident". Meanwhile, the escalating amount of "abnormal" experimental results creates impressive base for development Natural Sciences studies and for revision of outdated fundamental provisions in these disciplines. Here plays its invaluable role the rational system of fundamental researches aimed both at quality improvement of expert-training programs and at creation of the knowledge-intensive, highly intellectual technical solutions.

I.

An indicative example is training of experts for chemical and metal mining industries that in large determine economical capacity of many countries. It is well-known that today's mineral and raw sources of productions have radically changed. For example, the basis of modern mineral resources in metallurgy field is represented by polymetal ores that are too complex in mineralogical structure and, often, of poor grade, and difficult to process in the technological relation. Certain difficulties are related to deep processing of heavy, high-paraffinic and sulphurous oil and oil products. This situation requires a specific approach to creation of innovative technologies that will be deployed, and extension of product line in the petrochemical industry. To overcome existing difficulties in the use of natural raw materials, it requires fundamental knowledge of the processes happening in the considered systems. Specific knowledge about the physical and chemical properties of solid, gaseous and liquid objects is required. The science knows a great deal about the first two states of objects (although complex objects are not well-studied), but the liquid stage has not been studied well by the modern science. Yet, the science has no a uniform theory in regard to the liquid state of objects. It is the most striking example when erroneous conclusions in natural science studies led to huge losses in the innovative technologies research: the loss of time, material losses and huge labor costs. It especially influences planning and carrying out fundamental researches (including training of expert technologists) in the areas of science and techniques which directly deal with aggregate states of substances: liquid ~ steam, liquid ~ solid and steam ~ liquid ~ solid. It should be noted out that discussion about the structure of liquid systems, electrolytes in particular, has been on for more than hundred years [1]. One of the "official" scientific points of view in regard to the nature of inorganic water solutions was outlined in the beginning of the XX century by the outstanding Swedish scientist Svante Arrhenius, who was awarded the Nobel Prize in Chemistry in 1903. He was awarded "... for the services he has rendered to the advancement of chemistry by his electrolytic theory of dissociation". His theory was supported, in particular, by Nernst and Tubandt. They carried out experiments, which (in their opinion) demonstrated competency of scientific provisions of the theory of Arrhenius. It also formed the basis to consider Arrhenius's thesis as the scientific fact, but not the assumption. Over time this thesis became the "official" scientific point of view, and began to be called as "the theory of electrolytic dissociation".

Certainly, S. Arrhenius's theory - the outstanding scientist-chemist - had a considerable impact on development of technologies, especially the technologies using electrolysis process. Technologists had an opportunity to organize rather cheap production of metalized aluminum, metalized sodium, gallium and other metals, and also to organize effective purification of copper, nickel, etc. The success of this theory was caused by existence of high-quality raw materials in this area. Considerable changes in quality of the mineral raw materials used in chemistry and metallurgy, increased requirements to economy in metallurgical processes, and environmental protection require that realistic ideas about the structure, and in many cases, and knowledge of a microstructure of the condensed systems (especially liquid systems) become a necessary condition for creation of innovative technologies. Founders and developers of existing technologies in metallurgy and chemistry relied on thermodynamic and kinetic regularities of chemical processes or used empirical and, at best, semi-empirical approaches to the analysis of processes. Now, with creation of new highly intellectual equipment becomes obvious that fundamental bases are insufficiently fulfilled in such actual area of natural sciences as a ratio of influence of various types of energy (thermal, electric, energy of light, etc.) on chemical reactions and structural transformations in the condensed systems [2]. Fundamental research in this area to a certain extent demand accurately defined concepts which are applied to describe properties of many chemical systems and aggregate states of substances. One of examples is the melted condition of metal oxides. In November, 1960 at the First All-Union council for physical chemistry of melted salts and slag, a USSR academician A.N. Frumkin spoke: "… the structure of high-temperature systems is much less investigated as compared to the structure of water solutions, and its studying is very interesting task, and also the necessary prerequisite for creation of the general theory of a liquid state".

The corresponding member of Academy of Sciences of the USSR Ya.I. Gerassimov emphasized: "Participants … fairly believe that one of the most important problems of physics and chemistry – the problem of solutions, i.e. the theory of solutions can be resolved only by every possible development … of the molecular and statistical and thermodynamic theory of separate classes of solutions" [3]. Now, the studies on determining principles of liquid formation endure a new round in correlation of views on a microstructure of water solutions and high-temperature fusions [4, 5, etc.] . The modern science refers these researches and development of methods of forecasting such systems to the most actual fundamental and applied problems of physical chemistry. In other words, the solution of such problems, including, in natural science studies, in metallurgical technology is directly connected with realistic understanding of the nature and property of water systems in a wide range of parameters. It follows that receiving reliable initial data for development and deployment of a basis for innovative technologies in hydrometallurgy directly influences receiving effective results. If researches of solid objects are developed quite widely and bring new fundamental results and mutually agreed data on their physical and chemical properties, then researches of physical and chemical properties of solutions are generally based on the indirect data obtained as a result of various experiments. Unfortunately, physical and chemical properties of the concentrated and multicomponent solutions are studied very little. Meanwhile, this class of inorganic water solutions represents great practical interest as it is most often used in chemical and metallurgical technologies. The main difficulty in understanding of electrochemical processes have ideas of spontaneous electrolytic dissociation of solid junctions upon transition to solution. Doubts in reality of such ideas arose even during their formation. U. Sutherland showed that conductivity of solutions of electrolytes is inversely proportional to internal friction and degree of dissociation, i.e. existence of undoubted influence of a microstructure of solutions on transport of electric current. P. Fowler defined limits of applicability of Debye – Hueckel theory, especially regarding water solutions of high concentration. In general, the modern level of the theory doesn't allow to obtain numerical data on properties of solutions in the computational method and to predict their dependence on concentration and temperature, and experimental studying of solutions' properties lags behind requirement of science and practice. Recently, a number of research works where authors seek to receive more real ideas of a microstructure of various water solutions was published. For example, the works [4, 5, 6] state that liquids have a distant order which is presented to them by statistical ensembles of clots of molecules or clusters. Clusters have the following thermodynamic characteristics: superficial tension, potentials and even energy of their surfaces [7]. Energy of cluster formation in individual liquids lie in the range of kiloJoule/mole and below, and the solvent clusters of ionic couples of salts in liquid solutions lie in the Joule/mole - miliJoule/mole range [7]. The authors [7] assume that the thermal field (k - Boltzmann's constant, T – temperature, Calvin degrees) constantly destroys clots of molecules, but this process to be in balance with processes of their formation. A driving force of clot mass formation is cohesive - cooperation interactions of similar molecules. This assumption doesn't consider that the structure of liquid systems changes with temperature increase and this change can be quite considerable [8]. Authors [7] in a number of their works suggest to consider individual liquids and their mixes, and also polymers as nanoemulsions, and clusters of salts in solutions as nanosuspensions of germinal crystals. This assumption recognizes that clots of masses may be allocated and analyzed by standard physical and chemical methods perhaps only for organic solutions and polymers [9]. Yet it is impossible to do it for inorganic water solution, though there are researches directed on establishment of their microstructure.

The authors [7] consider that it is reasonable to expect that "in the solutions used in chemical technologies, clustering processes will take place as well. For a new stage of high-quality development of the chemical and biotechnological industry this understanding will play a crucial role in formation of competitive segments of the market in the 21st century". From the above short reasoning, complexity of a problem with use of inorganic water solutions in innovative technologies is quite obvious. A big complexity is also represented by clarification of mechanics of chemical processes on electrodes, especially on composite ones. This task became actual for all world science recently. Passing of chemical processes on electrodes caused interest owing to a number of the facts. For example, it is known that the compounds received by electrodeposition on the cathode can differ in singularity of physical properties and/or nuclear and crystal structure that often is followed by formation of metastable modifications [10, 11]. The physical nature of this phenomenon wasn't analyzed earlier in spite of the fact that the practical importance of electrolytic crystals doesn't raise doubts. It was established that the general structural regularities of electrolytic crystals defining their specific properties are related to a unique factor of electrodeposition, i.e. an excess density of electrons at the front of crystallization. The excess density of electrons particularly can be caused by chemical processes which happen along with release of electric energy. Such processes can provide occurrence of thermodynamically improbable reactions, but cause additional difficulties at their studying. So, the authors

[10, 11] found out that general regularities of formation of electrolytic phases are attributed to the excess density of electrons at their cathode sedimentation. This particularly leads to stabilization of some phases which are absent on the corresponding P-T (pressure - temperature) charts.

The existing theoretical statutes on liquid outflank many difficulties, especiallyliquids in physical chemistry that negatively influences creation of realistic base for development of innovative technologies. Sometimes these ideas of liquid create unsoluble contradictions in modern fundamental science in the explanation of transport properties of the condensed systems, especially regarding transfer of different types of energy and the mechanism of transport of substance (atoms, molecules, groups of atoms or molecules, etc.). In particular, such situation doesn't promote development of scientific base for the technologies based on employing resonant phenomena in the condensed systems when using oscillatory and pulse influences.

Now the greatest interest among researchers in the world raises an issue of microstructure of inorganic water solutions. Especially this interest increased in connection with attempts to use nanotechnologies for creation of new constructional materials of different function through application of phase transitions. Research of processes of structuring and structural and phase transformations in the condensed systems at the beginning of the XXI century came to the forefront in natural-science disciplines. They gain special importance when using the nanotechnologies applied to production of electronic equipment, in technologies of receiving metals, alloys and various materials with in predetermined physical and technology properties. Thus ideas of a microstructure of liquid metals start playing a more important role. For example,, the report of professor V. S. Kroposhin (The Moscow State Technical University of Bauman) [3] shows how important it is to know not only the structure of solid alloys, but also metal fusions, including, fusions of monometals. Possibility of transfer of nanotechnologies in production of a wide range of inorganic and organic materials is studied now worldwide in laboratories of various profile and in various fields of science. Transfer of nanotechnologies in the field of producing functional materials will naturally be followed by researches of methods of use of energy in the developed technologies. Research of transmission of energy in the condensed systems will have a direct practical focus. In turn, these researches are directly related to researches of processes of structurization. The enormous experimental material accumulated by science in the XX century on transport properties of various chemical compounds and substances gives the grounds for correction of a number of ideas of structure of the condensed systems, in particular, liquid and structural transitions in liquid systems. On the practical level, this experimental material creates prerequisites for purposeful formation of structures of the condensed systems not only by changes of chemical composition and temperature, but also under the influence of other physical factors. Realistic ideas of the principles of formation of liquid systems (and connected with it the mechanism of phase transition of the first sort) were already beyond pure academic interest. The practical aspect of this problem is a wide circulation of high technologies in production of materials with the predetermined functional properties (semiconductor devices, liquid crystals, etc.) demonstrates importance of management of structure of the condensed systems, especially, structure of liquid for optimization of technological processes. However, some fundamental representations in these issues don't allow to apply to the fullest completeness and flexibility of these theoretical representations for development of new technologies. The most indicative example of this interrelation is explanations of transfer of electric current through liquid and the principle of formation of structure of electrolytes. In the course of researches of structural transformations in liquids under the influence of different types of energy and transportation of electric current in electrolytes, the phenomenon of a coacervation of high-temperature oxidic fusions (electrolytes in modern meaning) under the influence of variation electromagnetic fields and mechanical oscillations was revealed [12]. Besides, anisotropy of conductivity of high-temperature fusions is revealed and influence of orientation of molecular dipoles on the value of fusion electric conductivity is demonstrated. Also, there was a number of findings in various exotic phenomena in conductivity of the fusions occurring under the influence of electromagnetic fields and electric current characteristics (for example, decrease of conductivity of fusion with temperature increase, increase of conductivity of fusion with fall of temperature, spasmodic change of conductivity, etc.). Also revealed an abnormally high electroforetic migration of solid particles. Established a possibility of chemical interaction of oxidic fusions with components of a gas phase with a wide chemical composition under the influence of pulse electric current (meander) [13]. At the same time deoxidizing gas can act as an oxidizer, and structural changes in fusion lead to loss of fusibility of oxidic systems. The given facts give the grounds for need of revision of the existing theoretical views of processes of formation of a microstructure of liquid (in particular, water solutions and oxidic fusions) and conductivity of liquid for interpretation of practical properties of these systems (the theory of electrolytic dissociation by Arrhenius, various theories of conductivity of liquid, etc.). In turn, the existing theories of conductivity of liquid only partially correspond to the realities and call for their improvement for introduction of high technologies in metallurgical and chemical production [14, 15].

Conclusion

The most important aspect of innovations is in applying results of modern fundamental researches into the course of training and is a dialectic approach and analytical reasonings in teaching it is natural science studies and application of new knowledge in teaching the main subjects at training of specialists with the higher education. Obviously, it will require correction of some scientific views and definitions in the nature of chemical reactions, power testaments, micro and macroproperties of substances in their interrelation [16, 17, 18]. Since the whole world is using a new paradigm in education, it will require feaguring out the way of overcoming conservatism in education in order to secure prerequisites of a sustainable development of society.

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