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DOI 10.1070/RC2004v073n01ABEH000863

Institute of Physical Chemistry of the Russian Academy of Sciences





This issue of the Journal comprises reviews written by researchers of the Institute of Physical Chemistry of the Russian Academy of Sciences (IPC RAS), one of the leading chemical research establishments of the Russian Academy of Sciences.

In 1929, Academician V A Kistyakovsky, a renowned physicochemist and a specialist in the field of complex colloid-electrochemical problems, was entrusted with the task of organising a colloid-electrochemical laboratory (CELA) under the aegis of the USSR Academy of Sciences. In 1934, the laboratory was granted the status of the Colloid-Electrochemical Institute (CEIN) of the USSR Academy of Sciences. Many prominent scientists, such as Academicians P A Rebinder, A N Frumkin, M M Dubinin, V I Spitsyn, B V Derjaguin, Corresponding Members of RAS G V Akimov, K V Chmutov, A K Pikaev, N A Izgaryshev, S Z Roginsky and Professors A D Gelman, Yu N Golovanov, I L Rozenfeld, N D Tomashev, N E Brezhneva, B A Zaitsev, A T Vagramyan, K M Gorbunova, *etc*., have worked at the Institute at different times. The development of many promising research areas in IPC RAS, such as physicochemical mechanics; physicochemistry of disperse systems and surface forces; sorption and adsorption processes; thin liquid and polymeric layers; corrosion of metals and alloys; electrochemistry and electrocrystallisation; radiochemistry and radiation chemistry as well as chromatography is associated with the names of these distinguished scientists.

At present, the multi-disciplinary fundamental and applied investigations carried out at the Institute are developing along the following lines:

— colloid-surface phenomena and adsorption;

— physicochemistry of nano- and supramolecular systems;

— radiochemistry and chemistry of high energy;

— physicochemical aspects of corrosion, electrochemistry, protective coatings and crystallisation.

The Institute has unique experimental facilities. In 2002, a centre for joint use of physical methods including electron microscopy and X-ray microanalysis, oscillation and electron spectroscopy, positron annihilation, ellipsometry, X-ray diffraction analysis, chromatoionic and mass spectrometry and atomic absorption analysis was organised within the structure of the Institute. The Institute possesses its own corrosion stations for conducting full-scale field tests in Moscow, Zvenigorod, Murmansk and Vladivostok and performs similar tests through a network of stations functioning within the structure of the Tropical Research Centre of RAS and located in different climatic zones of Russia. The Institute has at its disposal complex technological equipment for conducting accelerated tests and possesses a database on atmospheric resistance of various materials with different types of protection created on the basis of long-term observations. Other equipment includes a system for continuous monitoring and computer processing of meteorological data and corrosion parameters of tested materials, a computerised laboratory for static and dynamic autoclave testing of non-strained and mechanically strained materials in aqueous solutions at high temperatures and high pressures, four linear accelerators and four gamma-ray sources.

The Institute has in its structure a research-and-education centre consisting of two main departments (Inorganic, radio- and radiation chemistry and Physicochemistry of surface phenomena and colloid systems) and several research-and-education departments, such as 'Physical chemistry of polymers', 'Physicochemistry of supramolecular systems', 'Physicochemical basis of technology of composite materials', 'Adsorption and adsorbents', 'Chromatography and chromatographic instruments', 'Corrosion and protection of metals', 'Ion-exchange chromatography' and 'Physicochemical mechanics'. Postgraduate courses and four dissertation boards of the Higher Attestation Commission also function at the Institute.

The Institute collaborates successfully with national academies of sciences, universities and research establishments in the USA, Canada, Great Britain, France, FRG, Sweden, Finland, Japan, Korea, Australia and Italy. Researchers of the Institute take an active part in international symposia and conferences; their works are translated and published in many countries of the world. The Institute maintains close ties with large enterprises affiliated to the Ministry for Atomic Energy and the Ministry of Defense of the Russian Federation and some other state-owned institutions and carries out contract work for many manufacturing companies and research centres in France, Germany, USA, India, Korea and other countries.

At present, the Institute comprises proud of several scientific schools with rich traditions and great research experience in all the fields mentioned above.

The staff of the Institute is 920 people including two Academicians and three Corresponding Members of RAS, 70 D.Sci. and 295 Ph.D.'s.

Within the framework of the Programme 'Colloid-surface phenomena and adsorption processes', the Institute carries out in-depth studies on surface forces, stability of colloids and liquid films, adhesion phenomena and physicochemical mechanics of disperse structures and solids and develops theories of gas and vapour adsorption by microporous sorbents.

Some of the most recent achievements of the Institute are as follows: the development of a novel method for measuring parameters of porous structures of adsorbents; the proposal of a methodology for computation of contact angles of aqueous solutions of electrolytes on charged solid surfaces of various degrees of hydrophilicity allowing prediction of the stabilities and thicknesses of wetting films; the development of a new in principle technology for investigations into structure formation and flow processes of concentrated nanodispersed systems; preparation of carbon-based sorbents that allow purification of solutions of organic substances and aqueous media and ultimate purification of drinking water from dioxins and monitoring of the dioxin content in air, water and soil; elaboration of fundamentals of non-linear preparative multicomponent chromatography; development of novel procedures for studying structures of liquids in thin layers. An automatic unit for measuring surface and interphase tensions of liquids and wetting angles under static and dynamic regimes and for determination of critical concentrations of micelle formation developed at the Institute was awarded a diploma and a Gold Medal at the International Exhibition of Innovations, Investigations and Technologies (Brussels, 2001). Yet another development of IPC RAS, *viz.,* a unit for the conversion of a polarised light, was awarded a Silver Medal (Brussels, 2002).

A detailed description of this area of research is given in the reviews by N V Churaev, 'Surface forces and physicochemistry of surface phenomena', and N B Uriev, 'Physicochemical dynamics of disperse systems'.

The fundamental and applied investigations into the structures, phase equilibria, surface and diffusion phenomena in polymeric, polymeric-monomeric and filled systems are carried out within the framework of the Programme 'Physicochemistry of nano- and supramolecular systems' aimed at the elaboration of physicochemical principles for preparation, modification and stabilisation of polymeric coatings, adhesive mixtures and composite binding materials. Strategies for supramolecular design of planar systems are being developed; the effect of dimensional selectivity has been predicted and realised for the first time; two-dimensional polymeric networks with functional molecules and nanoparticles integrated into them have been prepared; the dependence of parameters of nanopores in novel optoelectronic materials based on porous silicon (both before and after oxidation) and artificial opals on the temperature of their processing has been investigated; a theory of colloid interactions of elastic surfaces and a theory of, and a method for, dynamic measurements of forces using atomic-force microscopy have been developed. The principles of the design of a novel class of 'two-dimensional' nanocomposite materials (polymer/metal) have been developed and realised and their feasibility as efficient catalytic systems, which represent elements of planar solid sensors, has been demonstrated.

Physicochemistry of polymers is discussed in the review by A E Chalykh and V K Gerasimov, 'Phase equilibria and phase structures of polymer blends' and physicochemistry of supramolecular systems, in the review by A Yu Tsivadze, 'Supramolecular metal complex systems based on crown-substituted tetrapyrroles'.

As regards physicochemistry of corrosion processes, electrochemistry, protective coatings and crystallisation, studies on kinetics and mechanisms of metal corrosion under natural (atmospheric, marine, subterranean) conditions are currently under way. Also being studied are mechanisms of controlled synthesis and effects of volatile and contact inhibitors of metal corrosion and saturation with hydrogen. A theory of acid resistance, passivity and local violations of the passive state of non-strained and mechanically strained construction alloys is being developed; elaboration of protective coatings against specific corrosion of rocket engine nozzles and thermal-power metallic equipment in the atmosphere of combustion products and in aqueous and gaseous heat carriers as well as studies on multifunctional metallic and composite coatings, hydrogen saturation and hydrogen-induced embrittlement of metals are being carried out.

These studies have led to the development of novel coating technologies for corrosion protection of metals under natural conditions and elaboration of theoretical and practical principles of corrosion-resistant doping of alloys with cathodic additives. Technologies for the production of stainless steels and alloys with optimised compositions, aluminium, copper, nickel, titanium and zirconium, and possessing high corrosion resistance have been developed. A series of novel highly refractory compounds and their heat-conducting compositions with protective (including diamond-like) coatings have been developed. Novel technologies for applying protective and functional galvanic and chemically reduced metallic coatings onto diverse articles have been devised. The mechanism of hydrogen-induced embrittlement upon application of electrolytic coatings has been established and methods for elimination of this defect in aircraft and rocket engineering have been developed. Fundamentals of vapour-phase protection of metals with organic corrosion inhibitors have been elaborated and a new industrial technology for the preparation of protective materials for rocket-and-space engineering has been proposed. A database of the interaction of hydrogen isotopes with thermonuclear reactor materials contacting with plasma has been formed.

This line of research is considered in the review by Yu I Kuznetsov, 'Physicochemical aspects of metal corrosion inhibition in aqueous solutions'.

In the field of theoretical radiochemistry, the following topics are being developed: quantum chemistry of transuranium elements and their derivatives; studies on various valence forms of radioactive elements in aqueous and organic solutions, salt melts, gas and solid phases; redox reactions involving ions of actinides; systematic studies into the synthesis of novel derivatives of radioactive elements, determination of their structures and the most essential properties; elaboration of the scientific basis of extraction and sorption processes for the isolation and purification of radioactive elements, studies of isotope effects in reactions of heavy elements, and physicochemistry of radioactive and irradiated solids.

In the field of applied radiochemistry, the following studies should be mentioned: elaboration of the physicochemical basis for safe disposal of radioactive wastes from nuclear-power energetics, burial of liquid radioactive wastes and safe operation of underground storage pits; development of novel and improvement of existing extractive, sorptive, *etc*., procedures for the isolation of pure radioactive elements; solution of miscellaneous radioecological problems and a search for radioactive sources for medicinal and other applications.

The main investigations in the field of theoretical radiation chemistry include an analysis of primary processes of interactions of the ionising radiation with various substances; studies of fast and superfast reactions in the condensed phase using pulse radiolysis; development of scientific principles for the application

of ionising radiation for modification of various materials; studies on radiation-chemical processes occurring in laser, optoacoustic and superconducting materials and polymeric media and the development of methods for predicting radiation stabilities of various materials and compositions.

The work in the field of applied radiation chemistry is directed to the use of radiation chemistry for solution of environmental problems (*e.g.,* decomposition of toxic substances, *etc.*) and to the development of methods for protecting structural materials from radiation corrosion. Novel radiation-resistant materials and compositions based on them are being developed and advanced radiation-chemical methods for preparation of novel materials for medicine, biotechnology and membrane technology and dosimetric systems for radiation control are being designed.

This line of research is covered in the reviews by N N Krot and M S Grigoriev, 'Cation – cation interactions in crystalline actinide compounds', and B G Ershov, 'Kinetics, mechanisms and intermediates of some radiation-induced reactions in aqueous solutions'.

Needless to say, the size of this issue cannot encompass the whole range of investigations carried out at IPC RAS. Therefore, all those who are interested in more detailed information about the Institute are invited to visit our web-site: http://www.ipc.rssi.ru.

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Director of IPC RAS