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A N Frumkin Institute of Physical Chemistry and Electrochemistry, Russian Academy of Sciences

This issue is composed of review articles prepared by staff members of the A N Frumkin Institute of Physical Chemistry and Electrochemistry, a top chemical institute of the Russian Academy of Sciences. The institute staff comprises more than 800 persons, including 9 Academicians, 10 Corresponding Members of the RAS, about 100 Doctors of Science and 260 PhD.

The Institute's history started in 1929 when the Colloidal Electrochemical Laboratory was founded in the Academy of Sciences. Five years later, this Laboratory headed by Academician V A Kistyakovsky was transformed into Colloidal Electrochemical Institute, which in 1945 acquired the name Institute of Physical Chemistry of the USSR Academy of Sciences. In 1957, the Institute of Electrochemistry of the USSR Academy of Sciences separated from it, and in 2005, it was united again with the Institute of Physical Chemistry.

The fundamental and applied research carried out at the Institute includes the following key areas:

— supramolecular and nano-sized self-assembling systems for modern high technology;

— development and study of new compounds and materials with specified properties and functions, in particular, those for biological and medical purposes;

— kinetics and mechanisms of electrochemical reactions, electrocatalysis, new chemical cells and fuel cells, electrochemical information systems, and membrane bioelectrochemistry;

— surface phenomena in colloidal dispersion systems, adsorption, physicochemical mechanics; chemical resistance of materials, corrosion and oxidation protection of metals and other materials;

— chemistry and engineering of radioactive elements including the development of safe processes for the processing of irradiated nuclear fuel and radioactive wastes and materials.

The scientific advances of the Institute are based on modern experimental and instrumental facilities, particularly, electron microscopy, X-ray microanalysis, X-ray diffraction analysis, small-angle X-ray scattering, X-ray electron spectroscopy, positron annihilation, atomic absorption analysis, gas chromatography/ionic mass spectrometry, ellipsometry, FT IR and Raman spectroscopy, luminescence spectroscopy, photoelectron spectroscopy and various versions of nuclear magnetic resonance, which make it possible to solve very complicated tasks faced by the physicochemical and engineering research. The Institute also has at its disposal a set of ionizing radiation facilities, test benches for accelerated corrosion tests and autoclave studies, its own corrosion stations for *in situ* climatic tests in Moscow, Zvenigorod, Murmansk and Vladivostok, a unique set of equipment for testing fuel cells and their components, and electron accelerators.

This instrumentation in the hands of highly skilled specialists present at the Institute made it possible to establish in 2002 a scientific and educational complex, which now comprises eleven scientific and educational centres covering various subject matters and two joint research groups having members from various universities where more than 500 students are being trained. More than 80 post-graduates take post-graduate courses at the Institute.

The Institute carries out joint research with the top universities and scientific centres of the USA, Great Britain, France, Germany and other countries. By agreements between the Russian Academy of Sciences, CNRS (France) and the Russian Foundation for Basic Research, three international laboratories were established: the Russian–French Laboratory for Materials Based on Macrocyclic Compounds, the Russian–French–German Laboratory for Radiochemistry and Colloid Chemistry and the European Laboratory 'Suprachem'.

During the period of existence of the Institute, several scientific schools with rich tradition have formed and are being successfully developed. These are the scientific schools of Academician P A Rehbinder, who discovered the effect of adsorption-induced reduction of the strength of solids (Rehbinder effect), Academician M M Dubinin, an author of the theory of volume filling of micropores and the Dubinin–Radushkevich equation, and Academician B V Derjaguin, who developed the quantitative theory of colloid system stability. Currently they are combined to form the subject area 'Surface phenomena in colloidal dispersion systems, adsorption, physicochemical mechanics'. Recent progress in this area includes preparation of high-performance carbon sorbents suitable for treating solutions of organic compounds or aqueous media and for post-treatment of potable water to remove dioxins, and for the analytical monitoring of the dioxin content in air, water and soil; development of a new method for determining the porous structure of adsorbents; development of theoretical grounds for non-linear preparative multicomponent chromatography; elaboration of new methods for investigating the structure of a liquid in thin interlayers and a fundamentally new method for investigation of structurization and flow of concentrated nanodispersed particles; design of an automated setup for measuring the surface and interfacial tension of liquids and the contact wetting angles in the static and dynamic modes and the critical micelle concentrations; design of a light conversion device; development of the superhydrophobic deicing coatings for aluminium and its

alloys and special hydrophobic coatings for decreasing the surface-leakage currents of silicone insulators. A topic of this subject area is considered in the review of V I Roldughin 'Nonequilibrium thermodynamics of colloidal systems'.

The school of Academician V I Spitsyn is being continued as the research into 'The chemistry and chemical engineering of radioactive elements, development of effective environmentally clean and safe industrial processes for irradiated nuclear fuel, radioactive waste and material processing'. Within the framework of this subject area, the quantum chemistry of the transuranium elements and compounds and the scientific grounds of extraction and sorption processes for isolation and purification of radioactive elements are being developed; new compounds of radioactive elements are being synthesized and their structures and properties are being determined; problems of radioecology are being solved; new radiation-resistant materials and compositions and new dosimetry systems to monitor the radiation situation are being designed. The concept of electron-beam waste-free processing of renewable non-edible plant raw materials to motor fuel components and intermediates for heavy organic synthesis consisting in the electron beam-induced destruction of lignin and cellulose materials at a dose rate of $1-6\ \mathrm{kGy\ s^{-1}}$ and radiation heating has been developed at the Institute. In this issue, this subject area is represented by the reviews of A V Ponomarev and B G Ershov 'Fundamental aspects of radiation-thermal transformations of cellulose and plant biomass' and S A Kulyukhin 'Fundamental and applied aspects of the chemistry of radioactive iodine in gas and aqueous media'.

The school of Academician A N Frumkin, who developed the theoretical grounds of electrochemical kinetics, is continued by the subject area 'Kinetics and mechanisms of electrochemical reactions, electrocatalysis, new chemical cells, fuel cells, electrochemical information systems, computer simulation of processes in electrochemical systems and membrane bioelectrochemistry'. This subject area includes the development and testing of the electrochemical hydrogen extraction module based on the membrane-electrode assembly of a medium-temperature (180 °C) fuel cell; new catalysts for fuel cells and electrochemical supercapacitors with a high specific energy; and the theoretical grounds of practically important electrocatalytic processes including capacitive deionization of aqueous solutions used in sea and saline water demineralization and production of hydrocarbons and alcohols from renewable raw material sources. One topic of this subject area is addressed in the review of Yu M Volfkovich and V E Sosenkin 'Porous structure and wetting of fuel cell components as the factors determining their electrochemical characteristics'. The works of the school of Academician V A Kistyakovsky dealing with corrosion destruction of metals and alloys and corrosion protection are continued by the subject 'Chemical resistance of materials, corrosion and oxidation protection of metals and other materials'. Exploring this subject resulted in the development of the theoretical principles of the corrosion doping of alloys with cathodic additives; development of steels and alloys based on aluminium, copper, nickel, titanium and zirconium with high corrosion resistance and with optimized composition; the development of foundations of vapour-phase protection of metals by organic corrosion inhibitors; design of the industrial process for the manufacture of protective coatings for rocket-and-space machinery, and the database on the interaction of hydrogen isotopes with fission reactor materials contacting with plasma. The review of Yu I Kuznetsov and Ya G Avdeev 'Physicochemical aspects of metal corrosion inhibition in mineral acid solutions by unsaturated organic acids' (in view of the insufficient capacity of the issue, this review will be published in issue 12, 2012).

The research carried out along new lines which reflect the advancement of the Institute are headed by Academician A Yu Tsivadze ('Supramolecular nanostructured materials based on macrocyclic compounds'), Corresponding Member of the RAS B G Ershov ('Fundamental and applied methods of radiochemistry and radiation chemistry in solving the problem of radiation safety of the modern nuclear power engineering') and Corresponding Member of the RAS L B Boinovich ('Surface phenomena in the systems with nano-sized items') and are undoubtedly based on the extensive experience of the scientific schools pioneered by the Institute founders.

Director of the Institute of Physical Chemistry and
Electrochemistry, Russian Academy of Sciences
Academician **A Yu Tsivadze**