

RADIATION CHEMISTRY AND PHYSICS OF SOLID SYSTEMS

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Since the seventies, intensive research on influence of ionizing radiation at various temperatures, intensities and gaseous mediums upon physical-chemical and electrophysical properties of different oxide systems, adsorbents, catalysts and materials of nuclear reactors were conducted in Azerbaijan with the intent to determine effective uses for radiation and heat components of nuclear energy [1-24].

It was established that radiation-chemical processes on the surface of zeolite-containing catalysts could create complementary active centers for oil hydrocarbon cracking. These centers lead to an increase in gasoline fractions yield and the decrease of unwanted products during catalytic cracking of oil fractions. Stable Lewis and Brønsted acid sites are produced as a result of influence of ionizing radiation and radiation-chemical processes with the assistance of adsorbed phases in the zeolite and zeolite-containing catalysts. Stable acid sites give rise to both the decrease of activation energy of catalytic oil hydrocarbon cracking processes and increased activity and selectivity.

Since 1977, there have been investigations to determine if nuclear energy can be used for hydrogen production, and transform it as a universal energy carrier. Thus was formed a new scientific direction in atomic-hydrogen energetics.

Radiation-chemical processes for the decomposition of water, carbon dioxide and hydrocarbons have been investigated using various solid catalysts with the purpose of increasing both ionizing radiation energy efficiency and the rate of hydrogen accumulation. The characteristics of the catalytic action of radiation in the radiolysis of water, carbon dioxide and hydrocarbons have been established. Radiation-catalytic action of solids during decomposition process of adsorbed substances consists of the following: absorption, transformation in the necessary energy forms of ionizing radiation, energy transfer in the special active centers to the adsorbed phase. It is experimentally established that it is the nonequilibrium charge carriers and excited states being formed under action of ionizing radiation in solids that take part in the decomposition processes of adsorbed phases on the surface of solids. The processes of energy transport and transmission of ionizing radiation energy to the surface states depend on the following: structure orderliness, composition, surface (S) to volume (V) ratio, i.e. S/V, band gap, and the presence of strong adsorptive centers on the solid surface.

The regularities of physical, physical-chemical and chemical stages of radiation-heterogeneous processes using oxide systems have been ascertained. Theoretical modeling of the absorption, transformation and energy transfer processes by gamma-quantum in oxide compounds have been carried out. Scientific bases of catalyst selection for radiation-catalytic substance decomposition have been suggested. The regularities of influence of absorbed radiation dose rate, temperature, and substance concentration in radiation medium on the yield of base products (H₂ and CO) during radiolysis of H₂O, CO₂, CH₄ and CH₄-H₂O system have been developed. Furthermore, effective ways to transform the ionizing energy radiation into energy carriers have been recommended

The scientific bases for the production of liquid and gaseous fuels from coals and oil residues by way of thermal and radiation components of atomic energy within the framework of the Atom-energy Program have been developed [25-34]. The following specific features of radiation-thermal conversion of carbon materials were established: weep of destructive and polycondensation processes depending on parameters of radiolysis; high-rate heating of coal at the impulsive impact on accelerated electrons; refinement of micro and transient pores of coal from tarry materials, etc. A semiempirical expression for the relation between optimum interval of temperature and the dose rate at which the maximum radiation effects in the radiation-thermal processes is observed has been obtained. 8 inventions have been made on radiation-thermal production of gaseous (H_2 - CH_4) and liquid fuels, carbonic adsorbents and desulfurization of carbonaceous materials based on these effects. Joint research has been conducted on the samples of Yatagan and Yenikoy lignites of Turkey with Istanbul Technical University, Dokuz Eylul University and Suleyman Demirel University. Interesting scientific results have been obtained in these researches.

After the Chernobyl accident, the issues concerning nuclear reactor safety and also radiation-science of materials have taken on special significance. The oxidation mechanisms of the fuel elements based on zirconium and zirconium alloy as a result of radiation-heterogeneous processes when contacted with water have been studied. Radiation-heterogeneous processes in the contact of zirconium and zirconium alloy with water accelerate both the protecting metal oxidation process and the beginning of the disastrous zirconium oxidation. Contribution of radiation-heterogeneous processes when the fuel elements are in contact with the heat carrier during both the metal oxidation process and accumulation of hydrogen in the active zone has been determined [35, 36].

Ionizing radiation energy is used for carrying out vulcanization of different types of synthetic rubbers. Conditions for producing corrosion-resistant synthetic rubbers using ionizing radiation energy have been determined. These rubber products are widely used in gas-and-oil industry [37-40].

Modification of physical properties for polymeric dielectrics [41], ferroelectrics, semiconductors [42 - 46] and oxide dielectrics under ionizing radiation has been carried out.

Change in electrophysical, electrotechnical, and piezoelectrical properties are observed at preliminary actions of gamma-quanta on polymeric and composite materials. Various semiconductor materials and devices are frequently exposed to ionizing radiation. Therefore, scientific data on radiation resistance and electrophysical properties of semiconducting materials and devices are of interest. Radiation resistance of GeSi monocrystals and p-n junctions may be controlled by either injecting special impurities into the composition of the monocrystal or changing the Si content.

Radiation defects in GeSi monocrystals generate new levels in the band gap. The effect of ionizing radiation on photocells made of GeSi, Si, GaAs, Ge and GaAs-GaAlAs has been studied. The regularities of the processes taking place in the photocells have been established. Methods to change the conductivity and sensitivity of the photocells have been developed.

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