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PROGRESS OF SOVIET CHEMISTRY IN THE STALIN PERIOD

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In the first years after the revolution many important scientific institutes were founded in the USSR. These included the Physicochemical Institute imeni L. Ya. Karpov, the State Optical Institute, and the Institute of Fertilizers. The work of existing scientific institutes and universities was expanded. The number of technical and scientific personnel available to the industry was greatly increased.

Within the scope of the First Five-Year Plan (1928 - 1933) and as a sequel to various decisions made by the government and the Party, chemical production centers of the greatest magnitude came into being in the Moscow, Leningrad, Gor'kiy, Volga, Donbass, and Ural regions, and in the borderlands. The Beresnikov, Solikamsk, Khibinsk, and other combines grew and developed. Large sulfuric acid plants and plants for the production of fertilizers, salts, and many other chemical products were founded. In 1932 the first full-scale plant for the production of synthetic rubber by S. V. Lebedev's process was started. This general development continued during the period of the Second Five-Year Plan (1933 - 1937).

The Third Five-Year Plan (1938 - 1942) was announced as the "Chemical Five-Year Plan." Although successful fulfillment of the plan was interrupted by Hitler's invasion, the chemical and industrial personnel proved equal to the strain imposed by the emergency: the necessary chemical products were supplied to war industry and to the army. For that purpose the creation of many new defense industries became necessary. During the war scientific chemical research did not cease.

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I. GENERAL AND INORGANIC CHEMISTRY

The development of inorganic chemistry after the revolution was closely connected with the rapid growth of industries producing acids, alkalies, salts, metals, and inorganic fertilizers. During the period of the Stalin five-year plans these industries acquired a reliable raw materials base.

In the field of physicochemical methods, N. S. Kurnakov concentrated on a study of the theoretical concept of the individual chemical compound and the resulting practical applications. He devised a new method of physico-chemical analysis for the study of chemical equilibrium by means of physical and geometrical procedures. By establishing the essential unity underlying diagrams of state and diagrams of composition, he developed a fruitful method for the discovery and investigation of new compounds.

Kurnakov organized the Institute of Physicochemical Analysis at Leningrad, and later the Institute of General and Inorganic Chemistry in Moscow. There and at other institutes (the Institutes of Applied Chemistry, High Pressures, and Halurgy at Leningrad, and the Institutes of Mineral Raw Materials and of Fertilizers and Insectofungicides at Moscow), extensive work on physicochemical methods and the chemical equilibrium was carried out. The last-mentioned institute has solved problems in connection with the total utilization of phosphorite and apatite deposits and has done a considerable amount of work on the conversion of other types of mineral raw materials. Kurnakov's own institutes have worked on the utilization of salt lake brines and of the Solikamsk potassium deposits.

From the viewpoint of military applications in World War II, Kurnakov's investigations led to the successful development of new metal alloys used in armament. The science of metal alloys in general has been considerably advanced by his methods, based on the geometrical interpretation of the phase rule combined with the application of topology to the study of chemical changes, the study of metal alloys on the basis of property-composition diagrams, and the possibility of distinguishing thereby between various chemical compounds and phases of an intermediate type. The work on metal alloys started by Kurnakov has been considerably expanded.

In the field of geochemistry, the names of V. I. Vernadskiy and Academician A. K. Fersman are most prominent. In fact, the new discipline of geochemistry, which deals with the application of energetics and thermodynamics to the study of processes leading to the formation of minerals and their distribution in the earth crust was founded by these two investigators. As for practical applications, Fersman deserves credit for the development of apatite-nepheline and metal ore deposits of the Kola Peninsula.

Extensive investigations on the chemistry and technology of rare and radioactive elements have been carried out in the Soviet Union. After 3 years of research, the first radium preparations were obtained in 1921 by V. G. Khlopin and the group working under his direction. In 1922 the State Radium Institute was founded. Khlopin's work on radioactive elements dealt with the conditions under which a real (thermodynamic) equilibrium of the microcomponent is established with regard to its distribution between the crystalline solid phase and the solution, and with the use of radioactive tracer elements in the study of the replacement of ions of various valencies by their isomorphs. He studied questions having a bearing on the application of isomorphous replacement techniques and relationships in the development of methods for the fixation of unstable compounds in the solid phase and their characterization.

Khlopin and his collaborators established that a microcomponent which is isomorphous with the solid phase is distributed between this phase and the solution according to the law for the distribution for a solute between two imiscible solvents. He also showed that multiple recrystallization of the solid phase takes place before a real equilibrium has been reached, and that this process of recrystallization replaces diffusion in the solid phase, which does not occur at low temperatures. With crystals of submicroscopic size this recrystallization proceeds very rapidly.

Khlopin and B. A. Nikitin used radioactive tracers in investigations of a new type of mixed crystals, the so-called Grimm crystals. There is a difference between ordinary mixed crystals, as defined by Mitscherlich, and Grimm crystals in which simple replacement is impossible. In the latter, whole lattice areas of the components must be replaced. Mixed crystals of this type do not form when the concentration of one of the components falls below a certain limit. Khlopin concluded from this that isomorphous substances must be classified from the viewpoint of the dynamics of formation of isomorphous mixtures.

In studying the adsorption of isomorphous ions on the surface of crystalline precipitates, Khlopin proved that the adsorption equilibrium is established in the majority of cases within 20 to 30 minutes, and that the adsorption of isomorphous ions does not depend on the adsorbent's surface charge unless there is a change in the solubility of the latter. Khlopin proposed a formula for the determination of the surface of crystalline precipitates by the method of adsorbing an isomorphous ion on that surface. He also devised new methods of fractional crystallization.

Khlopin has obtained valuable results in the chemistry of polonium; in general, he has concentrated on work in the field of radioactive elements, particularly their purification, enrichment, and separation.

Of considerable interest are the investigations of A. A. Grinberg in the field of coordination compounds. Some of his results are summarized in the monograph, "Introduction to the Chemistry of Coordination Compounds," published in 1945. The main subdivision of Grinberg's investigations are the stereochemistry of coordination compounds, basic and acidic properties of platinum coordination compounds, oxidation and reduction of platinum coordination compounds, the nature of bonds in coordination compounds, and their thermal stability. Grinberg's experimental results confirm Werner's theory on compounds having the coordination number 4. Using methods based on the interaction of isomers with substituents capable of cyclization, Grinberg was able to contribute to the technique of determining the configuration of coordination compounds.

His work on the acidity, basicity, and oxidation-reduction processes has broadened the understanding of complex ions in solution, thereby clarifying the nature of chemical equilibrium. The work on coordination compounds done by L. A. Chugayev and collaborators at the Leningrad Institute for the Study of Platinum and Other Noble Metals was continued after his death at the Institute of General and Inorganic Chemistry in Moscow. This group of investigators discovered the predominant effect of the trans-substituent on the reactivity of any one substituent in a coordination complex, and applied this relationship to the synthesis of coordination compounds.

Considerable progress in the field of rare elements has been achieved in the USSR. As a result of research carried out during the five-year plans, all technically useful rare elements are now being produced in the USSR by technological methods which in numerous instances are superior to those applied abroad. The investigations of A. V. Novoselova in this particular field are considered outstanding.

The heavy inorganic industry (acids, bases, salts, and fertilizers) has developed considerably as a result of prospecting and research done during the period under consideration. During the period 1928 - 1937 it became possible to export apatites, potassium salts, and other ores and minerals, and to discontinue imports in these classifications. The total industrial conversion of apatites with the utilization of all by-products has already been mentioned. The discovery of the largest deposits in the world of potassium, sodium, and magnesium (sylvinite and carnallite) in the Solikamsk region has given a boost to the production of concentrated potassium fertilizers combined with the manufacture of valuable by-products (magnesium, chlorine, bromine, alkalies, etc.). The discovery and utilization of deposits of boron, sulfur, arsenic, fluorine, and other minerals must also be noted.

A nitrogen industry of great capacity and potential was created to supply the country with nitrogen fertilizers. World War II showed that there was no lack of military explosives based on products of industrial nitrogen fixation. Soviet scientists and engineers have developed new methods for the production of nitric acid and its derivatives and have proposed new catalysts for the synthesis of ammonia. In this connection, the Soviet heavy machine and chemical apparatus construction industries have successfully accomplished the task of supplying high-pressure equipment.

A good example of the practical usefulness of work done by Soviet chemists is the intensification of sulfuric acid production. As early as 1928 - 1937 the per-cubic-meter yield of sulfuric acid towers could be increased by a factor of 2-3, thus surpassing the highest productivity indexes of foreign enterprises. High increases in productivity could also be achieved in other branches of inorganic industry.

New branches of the silicate industry producing refractories, acid-resistant materials, insulators, optical glass, and new types of building materials were created.

Although insecticides and fungicides are not, strictly speaking, inorganic compounds, they are classified with fertilizers as agricultural chemicals. Some new Soviet insectofungicides are organoelemental substances which are almost universally toxic to insect pests and diseases of plants, as well as to insects which transmit these diseases.

Stimulated by the electrification of the country, electrochemical and electrothermic industries developed rapidly.

Insofar as individual achievements are concerned, work done under the direction of I. P. Bardin culminated in the introduction of the open-hearth process with the use of oxygen. S. M. Voronov developed two new aluminum alloys for forging and die stamping. He also devised new methods of heat treatment. S. I. Vol'fkovich and collaborators developed a technological process for the total conversion of phosphate minerals resulting in the following products: phosphate fertilizers, nitrogen fertilizers, sodium fluorosilicate, and rare earths. S. D. Stupnikov, I. N. Kuz'minykh, and K. M. Malin have been prominent in developing and introducing methods for the intensification of sulfuric acid production.

II. PHYSICAL CHEMISTRY

After the October Revolution a number of physicochemical institutes were founded in the USSR. Among these are the Physicochemical Institute imeni L. Ya.

Karpov, the Institute of Physical Chemistry of the Academy of Sciences USSR, the Institute of Physical Chemistry of the Academy of Sciences Ukrainian SSR, and the physicochemical laboratories attached to organizations such as the Optical Institute and the All-Union Institute of Aviation Materials. Research in physical chemistry has been marked by an emphasis on reaction kinetics and surface phenomena because of the practical importance of results achieved in these fields. In recent years a considerable amount of work has been done on the physical chemistry of high molecular compounds.

Outstanding work on the photochemical activation of aromatic compounds was done by A. N. Terenin, who also launched a new technique for investigating spectroscopically high pressure reactions. V. N. Kondrat'yev has been active in the spectroscopic investigation of reaction kinetics and intermediate products (radicals) occurring in reactions. The results of many years of work in the field of reaction kinetics were summarized in his "Spectroscopic Study of Gas Reactions."

Research in the electrochemical field has been done by A. N. Frumkin. The following results obtained by him are noteworthy: In regard to the structure of the electric double layer, precise capacity values could be obtained for the first time and the diffuse nature of the layer proved experimentally. Investigation of the adsorption of electrolytes on carbon and platinum disclosed that there is an extensive region of adsorption phenomena involving dependence of the adsorption of electrolytes on the formation of an electric double layer on the surface of the solid adsorbent submerged in the electrolyte solution. The adsorption is determined by the magnitude of the potential jump across the dividing surface.

In the field of surface phenomena, P. A. Rebinder introduced new concepts characterizing properties of solids. In the course of Rebinder's work, new effects in the mechanical treatment of solids which are caused by surface layers and the addition of small quantities of surface active compounds were discovered. The effects in question are of considerable importance in mechanical deformation and mechanical working.

S. Z. Roginskiy's work on catalysts is worthy of attention. The results of his work demonstrate the presence of microcomponents acting as promoters in supposedly pure, one-component catalysts. He also formulated for the first time a rational theoretical basis for the preparation of catalysts by establishing that supersaturation of topochemical stages of the genetic /generating?/ reaction must take place for high activity to be achieved. Roginskiy's work is of practical value in that his results can be used for the improvement of industrial catalysts.

I. P. Krichevskiy, P. V. Bol'shakov, and D. S. Tsiklis have done outstanding work on the heterogenous equilibrium at high pressures. All standard textbooks of physical chemistry and treatises on the phase rule state that in a system in the equilibrium state several solid and liquid phases may exist, but only one gaseous phase is possible. In studying the effect of changing pressures on an ammonia-nitrogen mixture, Krichevskiy found that at pressures amounting to several thousand atmospheres separation into two phases takes place. The two phases have approximately the same density, but one of them contains more ammonia than the original mixture, and the other more nitrogen. To prove that two gaseous phases are present, it was necessary to exceed the critical temperature of ammonia, 133 degrees centigrade. In view of the fact that at a temperature of 148 degrees centigrade and at a pressure of 10,000 atmospheres there is still separation into two phases, no doubt is possible in regard to the actual coexistence of two gaseous phases.

A. I. Brodskiy has worked since 1934 in the field of isotopes and has achieved considerable success in the development of new methods and applications to scientific research.

Ya. K. Syrkin has worked on the constitution of boron-hydrogen compounds, dipole moments, dielectric constants of polar liquids, and the nature of the chemical bond. Syrkin and collaborators have determined more than 200 dipole moments of organic molecules. The results of these investigations are collated in the monograph, "The Chemical Bond and the Structure of Molecules."

I. B. Grebenshchikov has done work on the physical chemistry of glass. His investigations are of importance from the point of view of national defense.

Of great interest are the investigations carried out by N. N. Semenov and Ya. B. Zel'dovich in the field of chain reactions and the theory of combustion and explosion. In the course of these investigations a general theory which permits the calculation of chain mechanisms having any number of centers was developed. The interrelationships of chains and the combustion of initial materials can be taken into account in these calculations. On the basis of this theory, calculations of the oxidation of hydrogen and of the propagation of cold flame in various carbon disulfide-air mixtures could be carried out. These two investigators developed methods for the investigation of chemical properties of intermediate products without separating the latter from the reaction mixture. They created a theory of propagation and containment of hot flames, permitting calculation of the rate of flame propagation on the basis of known data of reaction kinetics. They also developed methods for the calculation of explosion rates on the basis of reaction kinetics in the explosion wave and proposed a general theory of rapid flames and explosion initiation.

Important investigations carried out by M. M. Dubinin on the adsorption of gases, vapors, and dissolved substances must also be noted. His investigations of the ultrafine structure of sorbents have contributed to knowledge of the structure of solid surfaces. In practice, Dubinin's work has helped to solve many problems in connection with the recovery of volatile solvents, means of defense against chemical warfare agents, and the production of industrial adsorbents.

III. ORGANIC CHEMISTRY

Soviet organic chemistry has developed in connection with the growth of the coal and petroleum industries and the utilization of forests and agricultural resources. The highest development may be noted in various branches of heavy and fine synthetic organic chemicals, the chemistry of motor fuels, and the production of high molecular compounds. During the five-year plans the following industries were substantially created, where none had existed before: synthetic rubber, heavy organic chemical production on the basis of cracking of gases, carbon monoxide, acetylene, motor fuels industry (catalytic cracking and other methods of crude petroleum conversion), and many others.

The work of N. D. Zelinskiy and his school had the greatest impact on the petroleum industry. Zelinskiy concentrated on transitions from one class of hydrocarbons to another and the utilization of hydrocarbons which were mistakenly regarded as unreactive. The synthesis of aromatics from petroleum raw materials and cyclization of open-chain hydrocarbons in general were accomplished on a practical scale due largely to studies of hydrogenation and dehydrogenation carried out by Zelinskiy and others. Zelinskiy for many years has also worked on the synthesis of alcohols, aldehydes, ketones, acids, and other organic compounds from petroleum raw materials. His work on catalytic cracking must also be regarded as significant. Zelinskiy's invention of the gas mask saved thousands of lives during World War I. The activated carbon proposed and investigated by him is still the basic protective substance against

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chemical warfare agents developed by all armies. Zelinskiy has also worked on many other subjects; there is hardly a field of chemistry upon which he has not touched during nearly 70 years of activity.

Quite outstanding also in the field of organic chemistry is the work of V. M. Rodionov, who carried out two main series of investigations, one on alkylation reactions and the other on the chemistry of beta-amino acids. The first line of investigation was launched by Rodionov nearly 25 years ago and was substantially completed by his work on the interaction of dialkyl anilines with aryl dicarboxylic acids in 1943. In 1920 it occurred to Rodionov that a by-product of saccharin production, p-toluene sulfonic acid chloride, could be used in preparing a superior methylating agent. His investigations in the field of beta-amino acids, in the course of which he developed a classical synthesis for this type of compound, were started in 1925 and completed in 1943, resulting in a final publication in that year. Rodionov has also worked on nitrogen heterocycles.

A. N. Nesmeyanov's work in the field of organometallic (or, more correctly, organoelemental) compounds continues a long-term trend in Soviet organic research, which traditionally concentrated on this class of substances. This investigator developed an excellent method for the synthesis of mercury organic and other organometallic compounds by the decomposition of double diazonium metal salts in the presence of reducing agents. By investigating the replacement of metal atoms in organometallic compounds with other metals, Nesmeyanov opened up extensive synthetic possibilities in this field. He has studied the addition of metal salts and nonmetal halides to unsaturated compounds and has also worked on fluoro-organic compounds, devising a method for the synthesis of acid fluorides, particularly formic acid fluoride. Nesmeyanov's work on metal carbonyls and in other fields of practical and theoretical organic chemistry must also be mentioned. K. A. Kocheshkov collaborated with Nesmeyanov in editing the series of monographs, "Synthetic Methods in the Field of Organometallic Compounds."

Kocheshkov's contributions to the field of organometallic compounds are also extensive and valuable. He has worked on organic compounds of lithium, sodium, magnesium, zinc, mercury (to some extent), silicon, tin, lead, antimony, and bismuth, and also on molybdenum and wolfram carbonyls. He concentrated particularly on elements of the fourth group. For lead compounds, he developed methods to synthesize aromatic derivatives which contain both lead and important functional groups in the nucleus. This has made it possible to avoid limitations inherent in the synthesis by means of alloys or organomagnesium compounds.

The following methods which enabled Kocheshkov to synthesize new types of lead organic compounds must be noted: reactions with salts of quadrivalent lead, disproportionations leading to highly arylated lead compounds, interaction of lead powder with organic lithium compounds, reactions leading to lead organic compounds containing a carboxylic group in the radical, etc. Kocheshkov has also done significant work on tin organic compounds. By means of a reversed disproportionation, Kocheshkov obtained compounds of the type $RSnX_3$, which are of fundamental importance for the characterization of tin in the periodic system of elements. He synthesized tetraaryl derivatives of tin containing functional groups in aromatic nuclei. Kocheshkov has made valuable contributions to branches of chemistry which form the basis for the solution of fundamental industrial problems.

A. D. Petrov has considerably advanced the industrial chemistry of motor fuels, particularly the synthesis of high-octane fuels. A series of his investigations deals with the selective hydropolymerization of acetylene under formation of isobutylene, isohexenes, and isooctenes, the isomerization of normal olefins into isoolefins, and the synthesis of a number of higher, hitherto unknown aliphatic and cyclic hydrocarbons. Petrov's synthesis of isobutylene from acetylene-hydrogen mixtures is a reaction which has important applications in the production of antiknock fuels and high polymer compounds. The new method of acetylene conversion will be applied practically in the near future, increasing the industrial potential and stimulating the production of calcium carbide. Petrov has demonstrated the possibility of increasing the degree of branching of olefins, and has successfully converted normal hexene into the maximally branched 2,3-dimethylbutene. A number of his investigations on the synthesis of hydrocarbons containing from nine to 24 carbon atoms have filled a hitherto-existing gap. The significance of the investigations in question is that the dependence of antiknock properties, congelation points, and viscosities on the constitution of hydrocarbons could be clarified. On the basis of these results, it has become possible to synthesize high-quality fuels and lubricants for Diesel and rocket engines.

The research of Yu. K. Yur'yev, published in the monograph "Transformation of Oxygen Heterocycles into Cycles Containing Other Heteroatoms or into Hydrocarbons," is of considerable interest. It occurred to Yur'yev that a connection between derivatives of furan, phrrole, and thiophene exists and that interconversion over the furan derivative may be assumed. He could experimentally confirm this hypothesis by establishing that furan reacts in the presence of aluminum oxide with ammonia, hydrogen sulfide, and hydrogen selenide under formation of pyrrole, thiophene, and selenophene, respectively. This reaction with the use of appropriate catalysts was successfully applied to tetrahydrofuran and tetrahydropyran. It is apparently applicable to all oxygen heterocycles, provided that a compound having reactive hydrogen atoms (this includes acetylene) is used as the second reagent.

P. V. Zimakov has specialized in the chemistry of ethylene oxide. In 1931 he discovered a new reaction of ethylene oxide with hydrogen sulfide. His research laid the basis for the production of diethylene glycol, triethylene glycol, and cellosolves. He solves in a highly original manner the problem of the technical conversion of propylene oxide into allyl alcohol. He has also studied the polymerization of ethylene oxide and succeeded in finding a method for stabilizing this product so that explosions are prevented.

G. P. Men'shikov has isolated two new alkaloids and established that they are derivatives of a new heterocycle, heliotridan, which forms the structural basis of many alkaloids.

Work of great importance has been accomplished by I. N. Nazarov. The results of his investigations were reported in two series of papers, "Acetylene Derivatives" and "The Chemistry of Vinylethinyl Carbinols." Nazarov discovered methods for the synthesis of various dienine hydrocarbons, vinylallyl ketones, and divinyl ketones. He developed to a considerable extent the chemistry of these unsaturated ketones and demonstrated that they can be transformed into oxygen, nitrogen, and sulfur heterocycles, and also into isocyclic five-membered rings. He studied complex polycyclic systems and devised a new and very simple method for the synthesis of the most diverse alicyclic compounds. By hydrogenating dialkylvinylethinyl carbinols, Nazarov obtained the most interesting conjugated diene alcohols and studied their chemical transformations and isomerization, comparing the properties of the products with those of corresponding alcohols serving as starting materials. Nazarov's work led to the synthesis of complicated physiologically active compounds of the alkaloid and steroid class with the aid of methods of acetylene chemistry.

A. Ye. Arbuzov is best known for his work on phosphorus organic compounds, a field in which he has carried out investigations of fundamental importance. He investigated the behavior of phosphorus acid and its derivatives, because phosphorus acid represents the classical type of tautomerism involving the shift of a proton between two adjacent atoms bound together, i.e., is an example of the simplest type of tautomerism. Arbuzov published a number of papers on the rearrangement of phenylphosphinous esters, a rearrangement which he discovered and which is named after him. In this connection, he discovered the catalytic effect of tertiary amines and investigated cases of isomerization taking place in the absence of alkyl halides.

In the field of fluoro-organic compounds, which is of great practical importance, I. L. Knunyants accomplished the synthesis of many fluoro derivatives containing functional groups, such as fluorohydrines, fluoroketones, fluorine-substituted acids and derivates, fluoroamines, etc. These syntheses are based on the action of hydrogen fluoride on olefin oxides. More than 50 fluorine compounds have been synthesized by this investigator.

Valuable from the viewpoint of practical applications is the work done by K. A. Andrianov and his collaborator, O. I. Gribanova, on silicon organic compounds.

A. Ye. Favorskiy and M. F. Shostakovskiy have developed a universally applicable method for the preparation of alkyl and arylvinyl ethers by the interaction of alcohols with acetylene at 150-180 degrees centigrade in the presence of caustic alkali. This reaction, which was discovered by Favorskiy, is carried out under pressure. The presence of an inert gas is not necessary. Vinyl ethers and their polymers are used as additives increasing the viscosity of lubricating oils and in medicine. An important application of vinyl ethers is their utilization as intermediate products in the production of acetic aldehyde by hydration. Shostakovskiy has done a considerable amount of work on vinyl ethers, continuing Favorskiy's investigations in the field of unsaturated compounds. Mainly as a result of the work done by Favorskiy and his school and as a consequence of the discovery of the fundamental reaction by Favorskiy, a great number of acetylene derivatives became accessible. Some types of synthetic rubber, high molecular compounds, film-forming substances, high viscosity additives modifying the properties of lubricating oils, and other valuable products could be synthesized over acetylene. Soviet organic research has developed this branch of chemistry on a broad scale.

S. S. Medvedev's work lies in the field of polymerization and polycondensation. His investigations on the mechanism of polymerizations induced by peroxides and peroxides combined with other substances (ketones, aldehydes, amines, and nitro derivatives) have led to a clear understanding of the first stage of polymerization. It could be shown that contrary to the accepted view peroxides are not catalysts, properly speaking, but have the properties of initiators. In other words, the decomposition energy of peroxides is utilized by the polymerization system. In this sense the action of peroxides is similar to that of light. Medvedev established that the polymerization of such vinylic compounds as vinyl acetate, styrene, methyl methacrylate, or vinyl nitrile is a homogeneous process, while in the polymerization of dienes, e.g., chloroprene or butadiene, the action of the wall plays an essential role. Medvedev also investigated two-component copolymerizations, including the systems divinylchloroprene, divinylnitriles, divinylstyrene, and acrylic ester - methacrylic ester, paying particular attention to the copolymerization of divinyl with acrylic acid nitrile.

Linear polycondensations were studied by V. V. Korshak, who tried to get away from the purely empirical, hit-and-miss methods applied formerly in this important field. Korshak showed experimentally that the most important factor determining the degree of polycondensation is the mutual proportion of starting materials or, to be more exact, the mutual ratio of active functional groups in the starting materials. In this connection, he proposed the use of the coefficient of equivalency as a constant which characterizes the process of

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polycondensation. He further showed that destructive reactions are caused by the action of the initial substances on the condensation products. As a result of these destructive reactions, condensation is limited and a uniform product results.

A. P. Terent'yev made the interesting and somewhat unexpected observation that pyridine-sulfur trioxide is capable of sulfonating substances which resinify under the action of acids. Terent'yev obtained sulfonic acids of many acid-sensitive substances, which he dubs "acidophobic." Included in this class of substances are thiophene, furan, pyrrole, indole, coumarone, some of the derivatives of the above, and a number of unsaturated compounds of the aliphatic and other series.

B. A. Kazanskiy has done outstanding work on the catalytic conversion of hydrocarbons. His work was concerned with the catalytic hydrogenation of cyclopentane and its derivatives under opening of the ring and with the catalytic aromatization of paraffin hydrocarbons. The first reaction was studied by him quantitatively. Data which permits defining the influence of the constitution and structure of hydrocarbons on their transformation into aliphatics were obtained in the course of this work. The synthesis of 1, 2, 3 trimethyl-cyclopentane by cyclization and subsequent conversion of the intermediate unsaturated ketone must be noted particularly. Three stereoisomers of the final product could be isolated. A. V. Koperina collaborated in the synthesis. Kazanskiy has also worked on the cyclization of paraffins having a quaternary carbon atom, and thereby clarified the mechanism of paraffin hydrocarbon aromatization on platinum catalysts.

In the conversion of hydrocarbons into valuable products of other types, the successful utilization of cracking gases in the USSR must not be passed over. The industrial application of syntheses of ethylene oxide, ethylene chlorohydrin, and ethylene glycol from ethylene and of acetone and isopropyl alcohol from propylene may be mentioned in that connection. Unsaturated by-products of cracking have served as material for the study of isomerization, alkylation, and polymerization, with the result that valuable motor fuels, lubricating oils, electrical insulation materials, and other products are being synthesized on an industrial scale.

Among those who have worked for many years in the field of petroleum chemistry is S. S. Nametkin.

An account of recent progress in Soviet organic chemistry would not be complete without the name of A. Ye. Poray-Koshits, who has done outstanding work in the field of dyestuff chemistry.

IV. BIOLOGICAL CHEMISTRY

A. N. Bakh, V. A. Engel'gart, M. P. Lyubimova, A. E. Braunshteyn, and S. S. Petrov are the most prominent investigators in the field of biochemical research.

A. N. Bakh has worked on respiration and biological oxidation catalysts. His work is not only theoretical, but has also influenced various technologies based on raw material of biological origin. Among these the drying of grain, baking, production of tea, and the tobacco and wine industries may be listed. Bakh is a founder of the Physicochemical Institute imeni Karpov and of the Biochemical Institute of the Academy of Sciences USSR. He is a permanent director of the latter.

Engel'gart and Lyublimova have worked on biochemical processes in muscle.

A. E. Braunshteyn and M. G. Kritsman discovered a new fundamental transformation of amino acids, the intermolecular transamination.

S. S. Petrov has also been active in the field of protein chemistry.

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