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6 November 1979

USSR Report

CHEMISTRY

(FOUO 1/79)

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NOTICE

Beginning with this issue, this report will contain additional material under the new subject category "Chemical Industry and Related Equipment" which heretofore had been included in the JPRS serial, "USSR REPORT: INDUSTRIAL AFFAIRS."

We expect the periodicity of this report to increase substantially with the addition of this material.

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USSR REPORT

CHEMISTRY

(FOUO 1/79)

This serial publication contains articles, abstracts of articles and news items from USSR scientific and technical journals on the specific subjects reflected in the table of contents.

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BUILDING MATERIALS

11TH MENDELEYEV CONGRESS ON GENERAL AND APPLIED CHEMISTRY--PLENARY REPORTS

Moscow XI MENDELEYEVSKIY S"EZD PO OBSHCHEY I PRIKLADNOY KHIMII: PLENARNYYE DOKLADY in Russian 1977 signed to press 30 May 77 pp 128-138

[Article by V. I. Dobuzhinskiy: "Scientific-Technical Problems of the Development of the Building Materials Industry"]

[Text] Developing and improving the building materials industry--the material-technical base of construction--is of decisive importance for the fulfillment of the vast program of construction work in the USSR.

The production of building materials, parts and structures is concentrated in various sectors of the industry. The main building materials are: cement and other binders, wall materials, asbestos-cement items, building ceramics, heat- and sound-proofing materials, construction and industrial glass, etc. They are produced mainly at the enterprises of the system of the USSR Ministry of Construction Materials Industry.

The building materials industry of the Soviet Union, with respect to the absolute production volume of basic building materials (cement, window glass, asbestos cement items, precast reinforced concrete) has surpassed the largest capitalist countries; 2.4 million people are working in it. Industrial-production fixed capital constitutes about 21 billion rubles.

Silicate building materials--cement, glass, reinforced concrete, asbestos cement, clay and silica brick, etc.--predominate in our country. The proportion of the output of the chemical industry and metallurgy is small in the overall balance of physical construction resources, but it is growing and will continue to grow in the future through increasing the production of building materials on the basis of polymers, economical shapes of rolled ferrous metals, aluminum, and wooden glued structures.

The following tasks are set for the present and the next five-year plan.

Expanding the output of new building materials.

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Developing at accelerated rates the production of cement, using the dry method, on the basis of the newest industrial processes. Increasing the output of high-grade and special types of cement--quick-hardening, pre-stressed and decorative.

Expanding the assortment and increasing the production of glass, including measured window, plate, heat-reflecting and architectural-construction glass. Introducing highly productive processes of two-stage forming of strips of glass and high-temperature founding of glass masses.

Increasing the production of large structures and individual asbestos cement items, as well as efficient heat- and sound-insulating materials.

Expanding the assortment and raising the quality of finishing and facing materials. Increasing the output of ceramic tiles, porous aggregates, items made of porous concretes, and also local building materials. Making broader use in the production of building materials of raw materials obtained as by-products and industrial wastes. Mechanizing and automating the production of wall materials.

The collectives of the enterprises and organizations of the ministry have fulfilled ahead of schedule the assignments for the Ninth Five-Year Plan for sale of output, growth of labor productivity and profits.

In the five years the total volume of industrial production rose by 42.2 percent. Some 507 million rubles worth of products above the plan were sold. Labor productivity increased by 34.9 percent, and profits--by 81.7 percent, which exceeds the assignments of the five-year plan. About nine-tenths of the increase in output was obtained through raising labor productivity.

Implementing measures specified by the program for technical reequipment in the Ninth Five-Year Plan made it possible to increase the output of products at existing plants with lower capital investments, as compared with new construction.

The scientists play a large role in the progress achieved by the building materials industry. The Central Committee of the Communist Party of the Soviet Union and the Soviet Government, in showing concern at all stages of socialist construction for outstripping development rates for the building materials industry, at the same time took measures to establish research and planning institutes, develop sectorial science and organize the training of skilled scientific and engineering personnel at the key chemical and technological, polytechnical and construction VUZ's in the country.

A considerable amount of scientific work is now being done at 33 scientific research institutes of the ministry, from research studies to putting the achievements into production. In collaboration with the workers of plants

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and planning and tune-up organizations, the collectives of the sectorial scientific research institutes are successfully solving specific problems of technical progress in industry. The ties are being made stronger between the sectors of science and the research organizations of related sectors and the scientists of VUZ's and institutes of the USSR Academy of Sciences. The USSR Ministry of the Construction Materials Industry and the USSR Ministry of Higher and Secondary Specialized Education have worked out a plan in accordance with which 110 scientific research projects are now being carried out.

Prominent scientists, well-known far beyond the borders of the Soviet Union, have laid the basis for domestic science of silicates. The fundamental research of A. A. Baykov, D. S. Belyankin, P. P. Budnikov, I. V. Grebenshchikov, N. N. Kachalov, I. I. Kitaygorodskiy, N. A. Toropov and other eminent scientists and teachers has made a great contribution to world science.

We will discuss some of the most important developments of domestic science with respect to silicates, introduced into production, and the tasks facing individual sectors of the building materials industry, the fulfilling of which requires that large-scale scientific research be performed.

The science of cement and the technique of cement production were enriched by the research and development of a complete industrial process with wide-scale use of the wastes of other sectors of industry.

The production of slag Portland cement was organized for the first time on a large scale using acid blast-furnace slags. A broad range of special new types of cement was created. The prestige of Soviet scientists and production workers in this field was confirmed at the Sixth International Congress on Cement Chemistry held in Moscow in September 1974.

Theoretical work on the application of the general laws of heat transfer and combustion to thermal processes in rotary furnaces, and studies on the movement of material and formation of clinker made it possible to establish a scientific method of calculating furnaces and their structures.

Large-scale research was performed in the field of the theory of clinker-formation and hydration.

Considerable progress was achieved in accelerating cement setting by changing the composition and structure of the clinker of fine grist and introducing additives--setting accelerants--which made it possible to create a whole group of special cements, including fast-setting and high-strength cements. It should be noted that the product list of cements put out by industry satisfies the most varied demands of construction.

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The first automated production control system using the Tsement-1 electronic computer was developed and put into operation at the Sebryakovskiy Cement Plant.

High-power main lines for producing cement by the advanced "dry" method, with furnaces with a capacity of 3,000 tons a day were constructed and put into operation. Highly productive self-pulverizing mills and slag dryers, new in principle, are being successfully put into operation, and have five times the productivity of those formerly used.

Right now the scientific research organizations of the cement industry are working on the design of a new industrial process for obtaining clinker at a low temperature, are developing a domestic design for decarbonization reactors which make possible a 1.5-2-fold increase in the capacity of the rotary furnaces with cyclone heat exchangers, and are studying the problems of intensifying the work of the furnaces.

Extensive new studies will be made in the field of creating high-strength cements that possess unified industrial-construction properties.

The study of concrete and reinforced concrete developed by Soviet researchers has gained worldwide renown.

Fundamental research has been performed on hydration and setting of binders and the kinetics of concrete setting under conditions of thermal processing, serving as the basis for developing an industrial process for reinforced concrete items.

Theoretical and experimental work on studying the role of the cement block and its effect on the structure and physical-chemical properties of concretes made it possible to design an efficient production process based on precise calculation of the relations of the basic properties of the concretes (including high-strength), mixtures and set articles.

Concrete will become more resistant to chemicals and freezing, its tensile strength will be increased and its setting time reduced. The use of additives that improve the properties of the concrete will be expanded. A concrete strength of 1400 kg/cm^2 will become common, and for special purposes concretes will be developed that have even greater strength.

Truly promising from the technical standpoint is reinforcing cement with high-strength and chemically resistant crystalline filaments made of silicates, which will increase the strength 5-10-fold with a considerable reduction in the weight. Formulas for cement-resistant fiber glass are being developed. Obviously, in the near future the industrial output of concrete based on glass-cement will be developed.

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The glass industry is characterized by the large scale of scientific research and planning-design work. At the Scientific Research Institute of Glass and its branches, the Institute of Silicate Chemistry of the USSR Academy of Sciences, the Institute of Glass Fiber and Glass Plastics, the Institute of Quartz Glass, at the departments of the Moscow Institute of Chemical Technology imeni D. I. Mendeleyev and other chemical-technological VUZ's, in scientific organizations of the Academies of Sciences of the Ukraine, Belorussia, Georgia, Armenia, Lithuania, at the scientific research institute of the Konstantinovskiy Avtosteklo Plant, and in the laboratories of major glass plants, research is being performed on all types of building, commercial and packaging glass, glassware, devitrified glass, slag devitrified glass and quartz glass.

Soviet scientists have enriched world science with respect to glass through their work on creating glass resistant to chemically corrosive reagents, with high and low electric resistance, with various softening points, increased mechanical strength, glass that permits rays of a certain wave length to pass through, with given values of light refraction, dispersion and coefficient of thermal expansion.

Soviet scientists and engineers have developed control of the crystallization of glass on a production scale, which made it possible to obtain materials with given chemical and physical properties--devitrified glass and slag devitrified glass, which are already being widely used in industry and construction due to their strength indicators, chemical resistance and high aging resistance.

A great deal of work has been done to intensify glass-making processes. Methods of continuous founding and production of items made from crystal and colored glass, decorated with rare-earth elements, permitting the production cycle to be reduced 10-fold and the fuel consumption cut in half, have been designed and put into widescale production. The production process for plate glass using the method of two-stage forming on a band of molten metal has come into wide use. The introduction of the new method increased labor productivity 3.25-fold, made it possible to reduce the production cost by 68 percent and raised the capacity of the equipment 2.3-fold, with a simultaneous reduction in capital expenditures. As a result of replacing obsolete equipment with new equipment, a production area equal to 16,000 square meters was freed. The introduction of the first line made it possible to obtain a yearly economic saving equal to 21.4 million rubles.

The research outlined in the glass industry should lead to profound qualitative changes in the very nature of the production.

Work will continue on solving the most important problems involved in intensifying glass production, with widescale introduction of automation, with the design of new structures for furnaces and glass-making machines and the design and introduction of new formulas for glass and methods for their thermal and industrial processing.

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A great deal of attention will be paid to the problem of strengthening glass. It is already possible to obtain glass fibers with extremely high strength under laboratory conditions. In practical work, however, glass strength proves to be considerably lower because of microfissures on the surface which are increased when exposed to the environment. Research is being performed on strengthening glass by applying metal oxides to the surface layer before the glass is annealed, and methods are being developed for using an ion-exchange process, as well as methods of strengthening on the basis of combining hardening, etching and film coatings. Research is to be done on intensifying the strengthening processes in supersonic and electric fields.

The result of this research is obtaining and industrial developing of production of new types of glass that will be 10-fold stronger, and should approach quartz with respect to the expansion coefficient and thermal properties. Items made from this glass will be included in the composition of engineering structures and building structures.

The USSR asbestos cement industry, the largest in the world, developed on the basis of broadly explored scientific research and planning-design work. A considerable amount of varied industrial equipment and mechanized flow lines has been designed and manufactured, and this made it possible to organize the production of discharge pipes withstanding a pressure of up to 15 atmospheres and large asbestos cement slabs. A thorough study was made of the fundamentals of the effect of the chemical-mineralogical composition and dispersability of cement on the production process for asbestos cement. A great deal of work has been done on the use of short-fibered types of asbestos from various deposits.

In this field, enlisting modern physical chemistry methods, the nature of the aggregative cohesiveness of asbestos fibers will be studied and efficient methods and equipment will be worked out to fluff up the asbestos. Methods will be devised to regulate the surface properties of the asbestos that will ensure the producibility of large asbestos cement slabs and long discharge pipes.

Methods new in principle are being developed for making asbestos cement items using the principles of extrusion and rolling.

Research will be carried out on strengthening items by introducing polymers into the composition, as well as through partial replacement of the asbestos with mineral fibers.

The ceramics production process has been radically reformed. In the field of ceramics technology classic works of both Russian and foreign scientists of the nineteenth and first half of the twentieth century are widely known.

The achievements of Soviet science in the field of developing new production processes for ceramic tiles are particularly undisputed. This was preceded

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by the study of fundamental theoretical problems of the physical chemistry of silicates and ceramic thermotechnics.

The introduction of scientifically substantiated high-speed systems of drying and annealing ceramic tiles, combined with design developments, made it possible to design mechanized flow lines with spray dryers and glazing-drying conveyors and slot roller-hearth furnaces surpassing all the processes known in other countries with respect to their technical-economic indicators. Suffice to say that the process makes it possible to reduce the production cycle from 65 to 72 hours to 1 hour.

Now the problem is posed of increasing the impact strength of ceramic items through reinforcement and selecting the cooling and annealing systems. The possibility of future development of plastic ceramic building materials will constitute serious competition for metal and concrete. Work is to be done to organize the output of thinner tiles, using the wastes from other sectors of industry.

Technical progress in the soft roofing materials and waterproofing materials industry was implemented mainly through the construction of large-scale new enterprises provided with modern industrial equipment. Work is to be done to develop the production of various types of roofing and waterproofing materials based on glass, to use reinforcement of ruberoid with polymeric or mineral fibers to increase its life, to use copolymers of bitumen, to develop new, nonrolled roofing materials (compositions) based on latex, polyurethane foam, etc. and to increase the strength of roofing materials for repeated bending and tensile rupture. The production of ruberoid with a flexible covering layer, perforated ruberoid and foam waterproofing materials is being organized on an industrial scale.

The prestige of Soviet scientists in the study, development and widescale use of items made from silicate concretes with autoclave setting is widely known.

Soviet scientists have developed the theory of hydrothermal setting of calcareous-siliceous materials, and have studied the conditions for the formation of calcium hydrosilicates in the process of autoclave processing. A new sector being developed--the production of large items made of autoclave setting concretes--is a great technical achievement for scientists and experienced practical workers in our country. A new production process for items made of porous concretes, using vibration, is now being worked out and put into operation.

Theoretical studies and experimental-industrial work on silicate concretes with autoclave setting will be thoroughly developed in the future; particular importance is attributed to the nature of the processes of the reaction of lime and siliceous components and to the study of the effect of new cementing formations on the properties of large items, which will make it possible in practical work to ensure the obtaining of a product with

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properties assigned in advance. Highly productive, fully mechanized and automated industrial lines will be designed and put into operation to manufacture enclosing and supporting structures, completely plant finished, made of porous and dense silicate concretes with "room-size" measurements.

Systematic scientific-experimental research has been developed at a number of scientific research institutes of porous aggregates and lightweight concretes based on them. Scientific fundamentals have been worked out for the production process for claydite, aggloporite, slag pumice, perlite and schungizite. Work is being done on comprehensive use of the ashes from thermal electric power stations and, in particular, obtaining cinder aggloporite gravel on their basis. A production process is being worked out for annealing claydite in a suspended state and from the fusion of silicate materials, as well as a process for cinder gravel in aggregates of the boiling layer.

A number of measures have been implemented in the wall materials industry to intensify the industrial processes and mechanize production.

There are plans for a fundamental improvement in the industrial process and the designing of automated plants, provided with highly productive equipment and automated control systems, and supervision and optimization of the industrial processes for the production of ceramic wall materials and silicate brick, ensuring an increase in labor productivity by 6-10-fold and a sharp improvement in the quality of the output.

Scientific research work to improve the production process and develop new types of efficient insulating materials has been developed on a broad scale.

Along with the development of production of items with increased rigidity and solidity made of natural raw materials, the thermal-insulation and sound-insulation fiberglass materials industry will be considerably developed.

There have been considerable changes in the production structure of mineralized items. The relative proportion of commercial cotton wool has been substantially reduced and the proportion of items made from it has been correspondingly increased [as published]. The production of efficient mineralized items is being developed. Mass production of acoustic tiles made of the Silakpor brand porous concrete has been organized.

The output of tested mineralized items makes it possible to expand the use of the existing lightweight structures and to develop new types of efficient structural members, as for example, triple-layer panels for apartment houses and industrial buildings, lighter-weight brick walls, etc. The replacement of claydite concrete (also a thermal-insulating material) with mineral slabs in the multilayer panels of exterior walls makes it possible to reduce the weight of 1 square meter of panel 5-fold and to reduce the total cost of the construction of the facilities by 20 percent.

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Extremely important theoretical research, experimental and industrial-test work is to be done, directed toward developing a fiber-forming unit that ensures obtaining nonreguline mineral fiber with complete processing of the melt, toward developing an automatic all-purpose smelting unit using gas or liquid fuel, ensuring the production of a silicate fusion from various types of raw material and toward developing automated conveyor lines for the production of building structures, fully plant finished, on the basis of mineralized items with increased rigidity.

The youngest science is the science of polymer building materials. The VNIIstroypolimer Scientific Research Institute, specialized in this field, in conjunction with a number of scientific organizations of the chemical and petrochemical industry, worked out a production process and certain types of equipment for producing various rolled materials, tiles and mastics, using polyvinyl chloride materials, without a base, as well as using a fabric and thermal-insulating basis. Efficient construction designs were developed for insulating buildings on the basis of polymers and synthetic resins, and gas-filled plastics were manufactured on the basis of them. Polyvinyl acetate mastics and polymer-cement and plastic-concrete formulas were developed.

A considerable amount of work is being done on expanding the raw material resources for polymer building materials from the wastes of the petrochemical industry.

Developing building materials from plastics will proceed along the lines of increasing their structural strength, life and fire-resistance. A wide range of decorative thermal- and sound-insulating materials, items for sanitation equipment, structures and materials for walls and floors will be produced on the basis of plastics and synthetic resins.

Widescale use of polyurethane and polyvinyl chloride will make it possible to produce slabs on the basis of flat and embossed asbestos cement sheets, with a rigid mineral and gypsum base, and reinforced fiber glass (trimming material, imitating natural stone, wood, etc.).

Varying types of laminated structures made from asbestos cement sheets, panels made from lightweight concretes, plastoconcretes, breccia, mosaic tiles from marble wastes, granite, etc. will be produced on the basis of resins of the epoxy type.

The use of resins of the melamine-formaldehyde type and various copolymers and latexes will make it possible to increase substantially, 2-2.5-fold, the resistance and life of soft roofing materials.

The fire-resistance of plastics will obviously be increased by introducing components that are combustion inhibitors.

It has now been established that introducing polymers into various building materials gives a fundamental improvement in their properties. On this basis new organo-mineral materials may be obtained in which the negative properties of polymers are neutralized.

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It is very efficient to inject polymers into the pores and capillaries of already finished building materials (concrete, asbestos cement, ceramics), and impregnating concrete with monomers, with subsequent special processing, increases the crushing strength from 200-300 to 1200-1500 kgs/cm^2, the strength of the clay brick reaches 1000 kgs/cm^2 and the transverse strength of asbestos cement--500 kgs/cm^2. This new production process will be widely developed.

Studies directed toward nature protection and the optimum use of natural resources, including the purification of sewage and introduction of advanced systems in water recycling, occupy an important place in the scientific research program. Theoretical studies and experimental work on drawing industrial wastes and by-products from other sectors of the national economy into the production of building materials are being expanded and intensified.

Using finely pulverized raw material masses in maximally rigid mixtures, with additives of surfactants, using vibration mixing, may fundamentally change the production process for a number of building materials.

In the future, extensive new studies will be made to develop the theory of processes of forming hardness and thermal transformations in materials created on the basis of phosphate binders.

The problem of obtaining materials with assigned properties, when using microadditives to raw material or a finished product, and with a directed change in the crystalline structures through the conditions for cooling the fusions or agglomerates is extremely interesting.

The tremendous progress made in chemistry has made it possible to reevaluate the long known fact of the presence of polymers among inorganic compounds. In addition to silica, polymeric compounds are formed by aluminum, phosphorus, sulfur and other elements.

Building materials such as glass, ceramics and cement have inorganic polymers as their basis. Glass ceramic materials--devitrified glass--a typical polymerical material obtained on the basis of silica--may serve as an example.

We expect that, as the result of the work of scientists in the field of study of the structure of glass, ceramics, cement and silicate concrete, compounds will be obtained that make possible a multiple increase in the strength, chemical resistance and other properties of these materials.

The workers in the USSR building materials industry will constantly put into effect the new ideas based on the achievements of science and technology of all sectors of the national economy and fundamental research in

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chemistry and other sciences, and will develop processes that are new in principle, thus solving the extremely important problem posed for the Soviet people by the Central Committee of the Communist Party of the Soviet Union of accelerating the rates of technical progress in all the sectors of the country's national economy.

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BUILDING MATERIALS

NORMS FOR CONSUMPTION OF MATERIALS AND PARTS PER MILLION RUBLES WORTH OF ESTIMATED CONSTRUCTION AND INSTALLATION WORK: CHEMICAL AND PETROCHEMICAL INDUSTRIES

Moscow NORMY RASKHODA MATERIALOV I IZDELIY NA 1 MLN. RUB. SMETNOY STOIMOSTI STROITEL'NO-MONTAZHNYKH RABOT--KHIMICHESKAYA PROMYSHLENNOST', NEFTEKHIMICHESKAYA PROMYSHLENNOST' in Russian 1979 signed to press 20 Nov 78 pp 4, 47

[Annotation and table of contents from book issued by Gosstroy and Gosplan USSR; Stroyizdat, 19,000 copies, 27 pp]

[Text] These norms were developed by planning organizations of the USSR Ministry of the Chemical Industry and Ministry of the Petroleum Refining Industry together with the Scientific Research Institute of Construction Economics, Gosstroy USSR, on the basis of the most economical current designs and with reference to the requirements of the "Technical Regulations for Economical Use of Main Construction Materials."

The following planning organizations took part in developing the norms: Giprokhim [chemical plant planning institute], Goskhimproyekt [institute for planning chemical enterprise facilities], Gosgorkhimproyekt [mining and chemical enterprise planning institute], Lengorkhimproyekt [Leningrad mining and chemical enterprise planning institute], GIAP [nitrogen and synthetics industries planning institute], Promstroyproyekt [general construction and sanitary engineering planning institute] (Moscow, Kiev), Giproplast [plastics and semi-finished products enterprise planning institute], Giproiv [synthetic-fiber enterprise planning institute], Giproorkhim [organic intermediates, dyestuffs and reagents enterprise planning institute], GIPI-LKP [paint and varnish industry planning institute] (Moscow, Leningrad), Gipropolimer [plastics industry planning institute], Giprokislorod [oxygen industry planning institute], giprokhimreaktiv [chemical reagents enterprise planning institute] (Donetsk, Khar'kov), Giprokauchuk [synthetic rubber industry planning institute] (Moscow), Rezinoproyekt [rubber industry planning institute] (Moscow, Yaroslavl') and GPI Santekhproyekt [sanitary engineering planning institute].

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CHEMICAL INDUSTRY

THE NATIONAL CHEMICAL INDUSTRY AT THE END OF THE TENTH FIVE-YEAR PLAN

Moscow KHIMICHESKAYA INDUSTRIYA STRANY V KONTSE DESYATOY PYATILETKI in Russian 1979 signed to press 24 May 79 pp 2, 62

[Annotation and table of contents from book by T. I. Sinyukova, Znaniye, 40,800 copies, 64 pp]

[Text] This booklet discusses the role of the chemical industry in the country's economy and its growing importance in the world economy. It is shown that as a result of changes in the raw materials base, the product breakdown and its utilization, and also of international division of labor, the increase of foreign trade and other factors, a geography of the chemical industry has developed. The shifts in distribution of the sector over the last 20 years are evaluated. The nature of the sector during the 10th Five-Year Plan is analyzed, the development of the chemical industry in the individual union republics and regions of the European and Eastern economic zones is analyzed, and the largest current construction projects are discussed.

This booklet is intended for a wide range of readers: scientists, propagandists, teachers and students in upper classes.

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FOOD TECHNOLOGY

COLLECTED PAPERS ON PROTEIN AND PEPTIDE CHEMISTRY

Dushanbe IZBRANNYYE TRUDY V OBLASTI KHIMII BELKA I PEPTIDOV in Russian 1977, signed to press 5 May 77 pp 2, 202

[Annotation and table of contents from collection of papers by Konstantin Titovich Poroshin, edited by Academician (Tadzhik SSR) P. M. Solozhenkin; Izdatel'stvo "Donish", 600 copies, 203 pp]

[Text] These papers deal with a critical problem of modern bioorganic chemistry: the chemistry of proteins and peptides, whose significance stems from the variety of biological functions which they perform in the living organism.

The book deals with four main areas: investigation of the chemistry of proteins and their hydrolysates; investigation of polycondensation of methyl and ethyl esters of amino acids and peptides; syntheses of activated esters of peptides, and through them of regular polypeptides, and the use of these polypeptides to simulate the structure of certain proteins; and the synthesis of alkaloid-peptide compounds.

The book is intended for a wide range of specialists working in bioorganic chemistry, natural products chemistry, microbiology, biophysics and biology.

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FUEL CELLS

REGENERATIVE FUEL ELEMENTS

Moscow REGENERATIVNYYE TOPLIVNYYE ELEMENTY in Russian 1978 signed to press 22 December 1977 pp 2, 167-168

[Annotation and table of contents from book by L. I. Kvasnikov and R. G. Tazetdinov, Atomizdat, 1600 copies, 168 pp]

[Text] Regeneration of the working components of electrochemical energy converters--fuel cells (TE)--makes it possible to create a new class of power production systems. The present book is devoted to analysis of the operating processes in power production units using regenerative fuel cells (RTE). It provides a classification of the various types of regenerative fuel cells and describes their main characteristics. Particular attention is devoted to systems with thermal regeneration of components: thermoelectrical converters (TEKhP) of fuel into electrical energy [thermocells]. The use of the techniques of nonequilibrium thermodynamics makes it possible to obtain relatively precise and at the same time general equations for the main parameters of the operating process. The range of components and electrolytes for different types of regenerative fuel cells is discussed, along with the kinetics of the working processes in thermocells and power systems based on them.

The book is intended for physicists, electrochemists and engineers dealing with problems of nonmechanical energy conversion and processes in high-temperature fuel cells with fused-salt and solid electrolytes.

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ORGANOPHOSPHORUS COMPOUNDS

UDC 541.515:542.91:547.551.42

STEREOSPECIFICITY OF INTERACTION OF CHAIR FORM OF THIOPYROPHOSPHONATES WITH ACETYLCHOLINE ESTERASE

Moscow IZVESTIYA AKADEMII NAUK SSSR--SERIYA KHIMICHESKAYA in Russian No 5, 1979 pp 1164-1165 manuscript received 10 Jan 79

[Article by I. A. Nuretdinov, N. A. Buina, Ye. V. Bayandina, F. G. Sibgatullina and D. N. Sadkova, Institute of Organic and Physical Chemistry imeni A. Ye. Arbuzov, Kazan' Branch, USSR Academy of Sciences]

[Text] The biological activity of organophosphorus insecticides is determined, by and large, by their ability to inhibit vitally important insect enzymes. Problems of making organophosphorus insecticides more selective are important in pesticide chemistry today [1].

We found that optically active thiopyrophosphates--with the general formula R(RO)P(S)—O—P(O)(OR)R (I) (R = C_2H_5)--prepared by the reaction of (+)- and (−)-O-ethylethylthiophosphonic acid with dicyclohexylcarbodiimide based on [2]--exhibit stereospecificity upon reacting with acetylcholinesterase of bull erythrocytes (ACE, creatine phosphate 3.1.1.7, Olayne Plant). Listed in the table are some data on the properties of thiopyrophosphonates (I) we prepared along with the constants of ACE inhibition with these compounds (K_2).

(a) Соединение	(b) Выход, %	d_4^{20}	n_D^{20}	$[\alpha]_D^{20}$	$[\alpha]_D^{20}$ (c) исх. кислоты	δ_{31P}	(d) K_2; 10^{-4}, л/мин·моль *
(f) (Ia)	90,0	1,1467	1,4680	−19,53	+8,05	−90, −25	3,69
(g) (Iб)	90,0	1,1466	1,4689	+31,72	−11,75	−90, −25	0,460
(h) (Iв)	87,5	1,1416	1,4690	Рацемат (e)		−90, −25	1,60

* Determined by potentiometric titration according to [3]. Elemental analysis is satisfactory.

Key:
a. Compound
b. Yield, percent
c. for initial acid
d. liters/minute·mole*
e. Racemate
f. Ia
g. Ib
h. Ic

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These data show that the configuration of the phosphorylating fragment of thiopyrophosphates (I) strongly affects their reaction with ACE. The strongest inhibitor of ACE is (Ia), eight times stronger than the isomer (Ib); the racemate (Ic) ranks intermediate between the optical isomers (Ia) and (Ib).

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PETROLEUM PROCESSING TECHNOLOGY

11TH MENDELEYEV CONGRESS ON GENERAL AND APPLIED CHEMISTRY--PLENARY REPORTS

Moscow XI MENDELEYEVSKIY S"EZD PO OBSHCHEY I PRIKLADNOY KHIMII: PLENARNYYE DOKLADY in Russian 1977 signed to press 30 May 77 pp 70-81

[Article by V. S. Fedorov: "Basic Directions of Scientific-Technical Progress in the USSR Petrochemical and Petroleum Refining Industry"]

[Text] An important event such as the 11th Mendeleyev Congress on General and Applied Chemistry is an integral part of the nationwide struggle for further development of our national economy. The successful completion of the Ninth Five-Year Plan showed the greatness of the labor victory of the Soviet people and the fruits of the gigantic political and organizational work that is being daily and painstakingly performed by our Communist Party, its Leninist Central Committee and the Politburo, headed by Comrade L. I. Brezhnev, general secretary of the Central Committee.

The collectives of the enterprises and scientific research and planning and design institutes of the petroleum refining and petrochemical industry, by using fundamental research and theoretical work, in cooperation with the institutes of the USSR Academy of Sciences, laboratories of the higher schools and organizations of the All-Union Chemical Society imeni D. I. Mendeleyev, have created the true prerequisites in industry for fulfillment of the Directives of the 24th party congress and goals of the Ninth Five-Year Plan.

About eight-tenths of the increase in production is ensured through raising labor productivity, which has approximately doubled.

A substantial production and scientific-technical potential has been created in the past years. New petroleum refineries and large petrochemical complexes and plants for the production of tires and industrial rubber and asbestos items have been put into operation.

The main portion of the growth of the industrial potential has been obtained by increasing the capacities, modernizing and expanding existing production facilities and enterprises:

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Over nine-tenths of the entire increase in capacities for primary petroleum refining has been obtained through this;

The entire increase in the production of rubber in volume will be obtained only through increasing the capacity of and modernizing the existing plants;

The tire production capacities will increase 2.1-fold as against the last five-year plan and over one-third of the increase will be obtained at the existing plants.

Modernizing and expanding the existing plants made it possible to exceed the assignments of the Ninth Five-Year Plan with respect to increase in output for each ruble of capital investments by over 25 percent, and to obtain an output from petroleum refining, petrochemistry and shale refining worth a total of over 800 million rubles. In these results too we can see the actual expression of the true force of scientific-technical progress.

The 10th Five-Year Plan, said L. I. Brezhnev, should above all be a five-year plan of quality, a five-year plan of efficiency.

The main lever for successfully solving this fundamental problem of the new five-year period has been and remains scientific-technical progress and its even more intensive acceleration in all areas of petroleum refining and petrochemistry. The growing demand for petroleum refining output requires that petroleum refining be soundly increased in the forthcoming five-year period.

Just as in the years of the Ninth Five-Year Plan, this problem will be solved through modernizing and expanding the existing plants. At the same time, in order to bring the petroleum product production facilities closer to the places of their concentrated consumption, completion of construction of six or seven new plants will be accelerated. Petroleum refining will be developed at high rates in the Ukraine, Belorussia, Turkmeniya and the Lithuanian SSR. Today, when mentioning this, it is particularly gratifying to stress the fact that in the 10th Five-Year Plan the output of petrochemical products will increase 7-fold and two major petrochemical complexes and a tire industry giant in the south and north of Kazakhstan will be put into operation.

The high growth rates of petroleum refining in the 10th Five-Year Plan are ensured by a reliable raw materials base, but major changes will take place in its qualitative structure--the proportion of sour crude and high-sulfur petroleum will increase to 80 percent in 1980. This thoroughly complicates the production process for motor and boiler fuels and makes it more capital-intensive.

The technical revolution has enriched our industry with powerful technical devices for forming the structure, quality and properties of motor and boiler fuels, lubricants and raw materials for chemistry and petrochemistry

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made from types of crude petroleum of any qualitative structure, as well as with the potential to change, by means of catalytic conversions, the output of many of these products as opposed to their natural content in petroleum. It is by using these precise devices that we were able, in the Ninth Five-Year Plan, to ensure an increase in the production of high-octane gasolines when refining low-octane and sour crude oils by over 3-fold. Here too, the conversion of essentially all the systems of catalytic cracking from amorphous aluminosilicate to highly efficient catalysts containing zeolite is very important. If this were not done, we would have had to construct an additional five or six new systems, spending up to 50 million rubles for this purpose.

In order to realize fully the potential for using catalysts containing zeolite, work is now being done to create in the future new, more efficient systems of catalytic cracking of heavy distillate and residual raw material with a unit capacity of up to 2.5-3.0 million tons a year, using new versions of catalysts containing zeolite.

Increasing the efficiency of catalytic systems of the reforming process had a substantial influence on the growth rates of production of high-octane gasolines, and along with this, of aromatic hydrocarbons. The All-Union Scientific Research Institute of Petrochemical Processes developed new bimetallic polyfunctional catalysts, series KR, the introduction of which, as was shown by experiment at the Novo-Ufa and Kirishi Plants, made it possible to raise to 83-87 percent the output of gasolines with an octane number of 95-97 (according to the research method) and reduce the pressure of the process to 15-17 atmospheres, as opposed to 35-40 in catalytic systems of the first and second generations. Work is now being done to prepare the conversion of existing and newly constructed reforming units to these efficient catalytic systems.

The conclusion of a large complex of scientific research and planning and design work will be the design of a highly efficient process of catalytic reforming ensuring a yield of up to 90 percent gasolines with an octane number up to 100, with the pressure of the process up to 10-15 atm., and the transition to constructing reforming units with a unit capacity of up to 2.0-2.5 million tons a year.

Great importance is attributed in the industry to accelerating the completion of developments and the introduction of the isoreforming process, which, combined with catalytic reforming, will make it possible to produce high-octane gasoline without using alkylate, which reduces the construction volume of systems for its production.

Developing and improving domestic systems of catalytic processing of sour crude and high-sulfur fractions of petroleum in a hydrogen medium resulted in outstanding achievements in the production of new, thermostable reactive fuels for all types of aircraft, as well as to an increase in the output of low-sulfur diesel fuels. Now too, great perspectives are being opened up

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in this field by the new GK-35 and GD-80 catalysts containing zeolite, created by the VNIINP [All-Union Scientific Research Institute of Petroleum and Gas Processing and the Production of Synthetic Liquid Fuel] and the Institute of Catalysis of the Siberian Branch of the USSR Academy of Sciences. The first increases the bulk speed of the hydrorefining process 1.5-1.8-fold, which will make it possible, at low expenditures, to increase the capacities of the existing units for hydrorefining of diesel fuels by 10-11 million tons; the second increases the bulk speed of hydrorefining of gasoline fractions 9-10-fold. These new catalysts will be very important for the powerful new catalytic reforming systems being planned.

The catalytic systems and industrial process of hydrocracking of heavy vacuum gas oil, developed by the VNIINP, opened up great potentials for producing base-stock oils with a viscosity index from 110 to 140, made from sour crude oils. This is very important. The point is that, by using the valuable natural properties of the oil fractions, with the aid of the process now used both in our country and abroad, it is possible to obtain, even from the best varieties of petroleum (and among them--petroleum from new deposits in Western Siberia and Kazakhstan) oils with a viscosity index of not over 95-110.

Putting into operation the systems created for the hydroisomerization process will ensure the production of oils with low viscosity values at temperatures below zero and a high yield of them from fractions of high-paraffin petroleum.

The introduction of these processes that we are planning will make it possible not only to raise the quality of the base-stock oils, but also to thoroughly expand the raw material resources for their production.

In the field of lubricants technical progress is above all observed in developing the production and use of special highly efficient additives. The industry is now producing more than half of the motor oils with these individual heteroatomic compounds, complex in their structure, possessing specific properties, and intensifying the cleansing, corrosion-inhibiting, oxidation-inhibiting, dispersive, viscosity and other specially assigned properties of mineral oils.

In the 10th Five-Year Plan the production of additives is being increased 1.8-fold, which fully provides for the national economy's need for high-quality lubricants.

Much has been done and is being done. The interests of this work, however, require an even closer uniting of the efforts of the scientists of the USSR Academy of Sciences, scientific research institutes and planning-design organizations of the industry, to overcome the lagging behind in this field through reinforcing the scientific-technical bases by means of a detailed study of the action of lubricants. There must be a search for new types of multifunctional, highly efficient additives and special synthetic oils on

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the basis of element-containing organic compounds that have higher bonding energy and, as a result, high thermostability, ensuring normal operation of mechanisms in a broad range of temperatures, and able to withstand the effect of the space vacuum, radiation and resist all types of corrosive mediums.

Now, when the outlines of the vast development of industry in 1976-1980 are appearing, we and the specialists in the petroleum and chemical machine building field are faced with the task of accelerating the development and design of highly productive equipment, in order to take an even larger step in the direction of optimum expansion of industrial units, bearing in mind the transition to construction of units for primary petroleum refining with a capacity of up to 12 million tons, instead of the 6-8 million tons that now hold the principal place in the construction of new and modernization of existing plants, which will make it possible to double or triple the unit capacities of the secondary processes. These powerful systems are a step forward in the cause of increasing the efficiency of capital investments and production.

It is quite clear that expanding the unit capacity of the equipment has a limit, determined by the technical potentials. In this connection an important means to further increasing the efficiency is the optimum unification of a number of logically interrelated industrial processes in the form of unified compact combined block-units with a high capacity, with automated control systems. This progressive trend has been broadly developed.

The principle of combining has been carried out in the GK-3 type deep petroleum refining units. With the construction of this type of unit in accordance with the pattern: primary and vacuum distilling--catalytic cracking--vis-breaking tars, as compared with the collection of analogous patterns based on local units with a similar capacity, the capital expenditures and metal consumption were reduced 1.6-fold, and the building area--4.5-fold, and the number of workers was reduced almost 3-fold. The yearly efficiency from operating this system in Angarsk was about 17 million rubles, mainly through the increase (by over 22 percent) in the output of motor fuels when refining Romashkinskaya petroleum as compared with the usual pattern.

For plants with light refining of petroleum, even more powerful type LK-6u units were developed and are now being used in accordance with the pattern: desalinization--stabilization--primary petroleum refining--reforming--hydrorefining with a gas fractionation system. This unit, recently put into operation at one of the plants, by refining up to 6-8 million tons of sour crude or high-sulfur petroleum a year, will produce gasoline with an octane number no lower than 93, thermostable reactive and low-sulfur diesel fuel (in amounts that are essentially at the level of their natural content in crude oil) and also mazut as boiler fuel (with a sulfur content depending on the petroleum being refined, from 2.7 to 4.5 percent).

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Certain other plants are now being constructed on this technical base. The assembly of the plant's capacity based on units of this type will soundly reduce the capital- and metal-intensiveness and labor-intensiveness in the process of operation and, ultimately, will ensure high efficiency in production and good quality for the motor fuels.

An important scientific-technical and economic problem is that of the efficiency of using the petroleum itself. In this connection too, by regarding mazut and its high-molecular fraction components as the second, basic raw material for the production of all types of modern motor fuels, oils and raw materials for petrochemistry, and by developing the scientific-technical bases for the study and testing of the operation of the GK-3 and LK-6u units, research and planning-design work will be carried out on a broad scale in the industry in the direction of designing powerful multipurpose combined units for thorough, virtually residue-free refining of mazut, and when necessary, the production of low-sulfur boiler fuels.

Today's achievements of science and technology in the field of catalytic break-up of high-molecular mazut fractions in a hydrogen medium open up a true potential for solving this problem, important in the economic aspect.

Recently completed on the basis of catalytic systems designed by VNIINP, VNIIneftekhim [All-Union Scientific Research Institute of Petrochemical Processes], GrozNII [Groznyy Petroleum Scientific Research Institute], Lengiproneftekhim [Leningrad State Institute for the Planning of Petrochemical Processes] and the Planning-Design Association is the preplanning development of the expansion of one of the plants already under construction to 24 million tons of deep petroleum refining a year, in accordance with the system: petroleum refining on type LK-6u units--hydrodesulfurization of the mazut--its vacuum distillation--catalytic cracking--coking of low-sulfur vacuum residue--hydrocracking of heavy distillates--ensures the output of high-octane gasolines, thermostable and low-sulfur fuels to 78-82 percent and of raw materials for petrochemistry and the production of low-sulfur electrode coke to 9-10 percent. The system introduced for thorough refining reduces the consumption of crude oil per ton of motor fuels up to 1.2-1.3 tons, as against 2.3 tons in the case of light refining, oriented toward primary production of boiler fuel. In other words, to produce equal amounts of motor fuels, in the case of light refining, not 24.0, but 44-46 million tons of petroleum are required, or 20-22 million tons more. This is no small difference. It considerably exceeds the level of petroleum extraction in Baku at the present time.

Therefore, the problem of thorough refining of mazut is above all the problem of highly efficient use of the petroleum--this unique and at the same time irreplaceable natural wealth of our native land. Both the resources of it and their use should be treated carefully--as is required by the law on underground resources recently passed by the USSR Supreme Soviet. The road toward this is now being laid by the achievements of scientific and technical progress in the field of refining heavy petroleum fractions, concentrated in mazuts--the residues of primary petroleum distillation.

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It is quite clear that intensifying petroleum refining will inevitably give rise to a reduction in the production of mazut, the proportion of which in the country's fuel-energy balance is still high. A reduction of mazut in the fuel-energy balance therefore requires a certain compensation through the use of other fuel-energy resources, namely gas, the prospected reserves of which several times exceed the resources of oil, coal, hydraulic power and the power from the heat-emitting components of nuclear electric power stations.

The problem of heavy catalytic refining of mazuts is an important one, and, at the same time, capital-intensive and complex from the technical standpoint. Here, perhaps the main concern is the task of ensuring high efficiency in the productivity of the catalytic stages of refining the mazut, as well as reliable and modern equipment design of the processes for the heavy refining unit, on the one hand, and on the other--the use of catalysts with a high degree of activeness and stability.

In speaking of this, I should like to emphasize the idea that obviously, the actual catalysts of each stage of the block-unit or local units--hydrodesulfurization and other catalytic processes of heavy mazut refining --persistently require more delicate treatment. The point is that the metals contained in the mazuts, particularly vanadium, as well as the nitrogen compounds, give rise to the irreversible deactivation of the catalysts, and asphaltenes, in turn adsorbed in the catalysts, lead to their intensified clogging with coke and consequently, to a reduction in the efficiency of the catalytic system as a whole. In order to realize to the maximum the potentials of the catalysts at all stages of the block-unit, we must, figuratively speaking, above all surmount a kind of "coking barrier," through introducing a stage of preliminary processing of the mazut, I would say, a stage of integral preparation of the mazuts that nesures thorough removal of the sulfur, nitrogen, metals, asphaltenes and other substances accompanying them that deactivate the catalysts, and thus opens the way to efficient use of modern methods of catalytic refining of mazuts.

In a word, there is to be scientific-technical research and development of an optimum method of preliminary preparation of the mazut. One of these methods may prove to be the process of high-temperature adsorption deasphaltization and demetallization of the mazut, using a circulating adsorbent either on the basis of coarse-pore aluminum oxide or on the basis of other adsorbents with a high coking capacity.

As is shown by experiment, thorough extraction of metals and asphaltenes in this case proceeds with quite high selectivity and relatively low losses of liquid fractions in the form of gas and coke. This or another method of preliminary preparation of the mazut, depending on the specific conditions for refining the petroleum, may be included either in the structure of the type LK-6u block-unit as a stage of preparing the mazut, or directly in the structure of the block-unit of its heavy refining system.

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The preliminary preparation of the mazut and catalytic processing of the raw material refined in this way affords real prerequisites for designing block-units for heavy refining of sour crude or high sulfur mazuts with a unit capacity of up to 5-6 million tons, with the output of motor fuels no lower than 65-70 percent. In the case of production of boiler fuel, however, it ensures a reduction in the sulfur in it to 0.5-0.7 percent, which is very important both for environmental protection and for the production of low-sulfur electrode coke.

The principles of optimum combination also find a place for themselves in petrochemistry. For example, on the basis of thermal pyrolysis of various fractions of petroleum, we were able, on the staff of the Nizhnekamsk Petrochemical Complex, to design a powerful combined system for obtaining lower olefins, dienes--butadiene and isoprene, and also benzene. This system is unique with respect to its technical designs and capacities. Start-up and adjustment work has now begun at the first such combined system.

In the 10th Five-Year Plan we are planning to construct several combined systems like this one. Some of them are already under construction at major petroleum refining and chemistry centers. These centers will be interconnected by ethylene pipelines, which will ensure the stable operation of the ethylene-consuming production facilities in the country, regardless of their departmental affiliation.

Scientific-technical progress in the petroleum refining industry and the modern achievements of chemical science and technology have created favorable conditions for outstripping development of petrochemistry in the 10th Five-Year Plan.

Perhaps the main factor in ensuring high development rates and efficiency in petrochemistry, along with a considerable--5-6-fold--increase in the unit capacities of various production facilities, is a sound improvement in the selectivity of a number of petrochemical processes.

At present, many industrial processes for the output of the basic product, and among them, ethylene and phenol oxides, acids of the aliphatic series and many others, have low selectivity, precisely in the range from 35 to 70 percent, which with large scales for the production facility leads to huge losses of ethylene, benzene, paraffins, xylenes, dienes and other types of expensive raw materials, now calculated by tens of thousands of tons and, as a result, creates a shortage of it.

Therefore, increasing the selectivity of chemical conversions is becoming one of the most important tasks of chemical science and, in our opinion, the degree of selectivity should be one of the basic criteria for evaluating the trends in scientific-technical research, developments and choice of the processes for executing them in industry.

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In mentioning raising the selectivity of the processes of chemical technology, I should like to note that today the catalytic systems for the production of glycols made from ethylene oxide with a selectivity of 95 percent, oxidation of isopropylbenzene into phenol with a selectivity of 93-95 percent and the synthesis of other products with similar yields, developed by NIIMSK [Scientific Research Institute of Monomers for Synthetic Rubber] and other institutes of the industry, in conjunction with institutes of the USSR Academy of Sciences, are putting us in a good situation.

An analysis of the state of achievements in domestic and world science and technology in the theory and modern methods of catalysis indicate that we are already justified in demanding from science the invention of processes with a selectivity of at least 90 percent of the theory.

An important means of increasing the efficiency of capital investments and production is also a reduction in the stage-nature of the syntheses and a transition to simpler, but more reliable industrial processes for obtaining the specific product. Modern achievements in chemical science are increasingly confirming this potential. Along with the successful industrial accomplishment of direct oxidation of ethylene into acetaldehyde, a true perspective has appeared for replacing multistage processes with low- or single-stage processes at production facilities:

For butadiene (by oxidizing dehydrogenation of butane); aliphatic alcohols (from paraffin); glycol (directly from ethylene); methylethylketone (from butylenes); isoprene (from isobutylene and formaldehyde) and certain other highly promising developments of NIIMSK, VNIIPAV [not further identified], VNIINeftekhim, VNIISK [All-Union Scientific Research Institute of Synthetic Rubber imeni S. V. Lebedev] and institutes of the USSR Academy of Sciences.

On this plane, and on the plane of the problems which were mentioned above, a great contribution to the development of scientific-technical progress in the petroleum refining and petrochemical industry will be carrying out the fundamental directions in the development of natural and social sciences in 1976-1980, worked out by divisions of the USSR Academy of Sciences with the participation of scientific councils on the most important problems and approved by the Presidium of the USSR Academy of Sciences.

Also attesting to the achievements of domestic chemical science and its unlimited potentials is the scientific-technical progress in the field of producing rubbers, the output of which will increase 1.7-fold in the years of the 10th Five-Year Plan, and of stereoregular elastomers--approximately 2.4-fold, which will make it possible in just the years of this five-year plan to reduce the consumption of natural rubber by over 2.5 million tons and to retain about 1.5 billion rubles in the country's hard currency fund.

The fruitful work of the scientists of the collectives of VNIISK, VNIIMSK and many other institutes of the industry and institutes of the USSR Academy of Sciences, many of whom are participants in this congress, and of the

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innovative workers, engineers and technicians of the synthetic rubber industry has been crowned by the establishing in our country of large-scale production of various types of synthetic rubbers.

The chemistry research on polyisoprene showed for the first time the potential for control of the growth and structure of the molecular chain and established the fundamental conformances to principle in the field of ion-coordination catalysis, which enriched polymeric science as a whole, and information on the nature of the active centers of polymerization of paired dienes, obtained by the method of nuclear-magnetic resonance, and made it possible for the first time for our scientists to propose a mechanism, common for all dienes, for forming polymeric chains, based on the determining role of the structure of the allyl link at the end of the live chain of polydiene. It is on this basis, by modifying the catalytic systems, that we have succeeded in producing polyisoprene with almost double the productivity of equipment and output of rubber, and in raising its quality to the level of natural rubber and, what is most important, in creating the conditions for an increase in the 10th Five-Year Plan of the output of this elastomer at existing plants. This program has already been put into operation.

While noting the progress in science and technology in producing stereoregular elastomers, we will discuss certain tasks in this field and the directions of accomplishing them in the near future.

First of all the search must be continued for new catalytic systems, as well as for modifying agents that increase the stereospecific nature of the catalysts studied, in order to achieve the maximum, close to 100 percent, content of 1,4-cis-structure in the elastomers, especially since VNIISK, working in this direction, has reported the latest achievement--rubber has been obtained with a content of 98 percent 1,4-cis-structure.

There are also certain problems in the field of designing new types of elastomers and, particularly, in the synthesis of stereoregular carbon-chain polymers through polymerization of cycloolefins with the scission of the ring and obtaining polymers of the most varied structure, including trans-polypentanamer, since its use in a mixture with isoprene rubber appears very promising in order to attain favorable properties of both elastomers.

There is great importance in the polymerization with scission of the ring of cyclical oligomers for the production of polybutadiene that does not contain 1,2-links, as well as for obtaining the alternate copolymer of butadiene with isoprene and a number of other new polymers.

Also reflected in this connection in the work plans of the industry's institutes are:

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The synthesis of new types of rubbers for general purposes--alternate copolymerization of dienes with olefins, especially since data have already been obtained on the valuable complex of properties of alternate copolymers of butadiene with propylene;

The development of the synthesis of liquid rubbers, which opens the way to a production process, new in principle, in the tire and industrial rubber industry, namely the transition to completely automated continuous processes for manufacturing items by casting methods, with a considerable reduction in the production areas and heavy equipment, rise in productivity and improvement in work conditions.

At the industrial institutes and institutes of the USSR Academy of Sciences work must be intensified in the following directions:

Designing new elastomers which should guarantee long operational life for the items made from them, with retention at the same time of their shape and elasticity at temperatures of 300°C and over;

Increasing the thermal stability of polymers on the basis of working on the synthesis of block-copolymers, the main chains of which are constructed from flexible blocks which have a low glass transition temperature and from rigid high-melting blocks;

Developing work on designing fluorine-containing elastomers with good low-temperature properties, and on the synthesis of rubbers that have substantially increased resistance to oxidation destruction, as well as designing elastomers that combine good frost-resistance, high oil and gasoline-resistance, acid-resistance and combustion-resistance.

It is quite understandable that creating a broad range of elastomers for both common and special purposes is not an end in itself, but a means to producing a quality of structural rubber material with a given set of properties that provide for the needs of the most varied sectors of the national economy, culture and everyday life in man's society.

Now, with the tremendous scale of elastomer production, the main problem is that of providing them with the production of monomers. The point is that a certain break has been revealed in the industry between the growth rates of the production of elastomers on the one hand and on the other--the production of monomers, chiefly butadiene and isoprene.

The situation is also somewhat complicated by the fact that in the European part of the country the resources of butanes and pentanes have been virtually exhausted.

In a word, the problem of monomers is a key problem. We will solve it primarily on the basis of accelerating construction in the homeland of D. I. Mendeleyev of the Tobol'sk Petrochemical Combine. At this combine, on the

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basis of huge resources of butanes and pentanes, contained in the casing-head gases in the extraction of petroleum in Western Siberia, an extremely large-scale production facility for monomers--divinyl and isoprene--will be established. The synthesis of monomers on the basis of the lower olefins, chiefly ethylene and propylene, with the aid of the reaction of dimerization, codimerization and disproportioning of double bonds in the olefin molecules occurring in the presence of metalloorganic complexes, will be completely new and truly modern. Carrying out these trends in synthesis will make it possible, by using the potentials of thermal pyrolysis of hydrocarbon raw material, which is available at any petroleum refinery, to ensure accelerated development of the production of butadiene, isoprene, the higher olefins and other monomers from a small number of initial olefins.

There are also promising potentials here for the synthesis of linear bifunctional monomers, each containing two double bonds at the ends of the alkyl chain. These monomers, the practical value of which is obvious, are formed with a high yield in the disproportionation of ethylene with cycloalkenes.

The process of pyrolysis is essentially a sort of basic connecting link, opening up the actual possibility of establishing major comprehensive production facilities not only for monomers for synthetic rubber, but also for many other functional derivatives of hydrocarbons.

I should like to stress the fact that chemical science and its present-day discoveries are a source of unlimited potentials for increasing the efficiency, the road to which is being laid by cooperation and comprehensive development of petroleum refining and petrochemistry.

Our country's high level of industrial development, the achievements of science and technology and the tremendous resources of oil and gas--the technical basis of the petroleum refining and petrochemical industry--are creating truly favorable circumstances for the fulfillment of the complex tasks of all-round development of the petroleum refining and petrochemical industry in our country in the 10th Five-Year Plan of quality and efficiency.

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PHOSPHORUS INDUSTRY

11TH MENDELEYEV CONGRESS ON GENERAL AND APPLIED CHEMISTRY--PLENARY REPORTS

Moscow XI MENDELEYEVSKIY S"EZD PO OBSHCHEY I PRIKLADNOY KHIMII: PLENARNYYE DOKLADY in Russian 1977 signed to press 30 May 77 pp 82-102

[Article by S. I. Vol'fkovich: "Problems of Phosphorus"]

[Text] It is possible that among some chemists the question arises as to why, at the plenary session of the 11th Mendeleyvskiy Congress, out of the 107 elements of the Periodic Table of D. I. Mendeleyev, one chemical element --phosphorus, which is contained in the earth's crust in an amount of about 0.1 percent (according to Clark) and moreover is not newly discovered, but has a history of 300 years--is the subject of a separate report. There are several reasons for this.

In the first place, phosphorus and its compounds play a key role in the biology of man, plants, animals, microorganisms and other bearers of life. "Phosphorus is the element of life and thought," wrote A. Ye. Fersman. But elemental white phosphorus and a number of its compounds are also poisons that have a toxic effect on the vital activity of organisms. Forty years ago V. A. Engel'gardt and M. N. Lyubimova discovered the energy role of phosphorus in living organisms. A study was made of its varying, including its therapeutic, effect on many physiological processes.

Fertilizers containing phosphorus have been used for about 150 years, and their world production in 1973 reached 33 million tons for P_2O_5, for which about 300 million tons of phosphate raw material was extracted from the underground. There is a rapid growth of the production and use of fodder agents containing phosphorus in livestock breeding, as well as the use of compounds containing phosphorus in the production of a number of food, medicinal, pesticidal and other bioactive substances.

In the second place, phosphorus and its compounds have a broad and very varied industrial use. Elemental phosphorus is not only a "bearer of light" (this is the meaning of the word in Greek), but a number of its inorganic compounds are used as fire-proofing, heat-resistance and binding substances. Many of its compounds have complexing and polymerizing, plasticizing, ion-exchanging, dehydrating, water-softening, lubricating,

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surface-active, flocculating, stabilizing, metal-corrosion-inhibiting and other properties. From elementary textbooks the use of phosphorus is known in defense equipment such as smoke-forming and incendiary devices, used in compounds with sulfur and certain resins in the last few wars.

In the third place, the chemistry and technology of phosphorus, its oxides, hydrides and halogenides of phosphoric acids and many thousand other compounds of it (particularly organic) and the study of their structure and physical-chemical properties are of great theoretical scientific importance. This interest, which does not weaken, but intensifies with each year, draws continually growing attention and increases the flow of research of numerous chemists, biologists, geologists, technicians and other specialists. It is sufficient to recall the works of A. Lavoisier, J. Liebig, F. Veler, G. Sheyele, D. I. Mendeleyev, D. N. Pryanishnikov, G. Tamman, A. Ye. Arbuzov, E. V. Britske, Ya. V. Samoylov, A. Ye. Fersman, V. N. Ipat'yev, A. A. Belopol'skiy, P. Bridgeman, E. Tillot, A. Mikhailis, F. Waggaman, R. Khignet, N. Vitting, J. Van Weser, Ya. Kobayashi, G. Koran and also our domestic contemporaries N. N. Semenov, M. I. Kabachnik, A. V. Kirsanov, V. A. Engel'gardt, I. V. Tananayev, N. N. Mel'nikov, B. A. Arbuzov, A. N. Pudovik, I. F. Lutsenko, N. N. Postnikov, M. Ye. Pozin, A. B. Bekturov, M. I. Nabiyev, Yu. N. Khodakov and many others.

Despite the large number of research works, there is still a great deal in the chemistry of phosphorus and its compounds that is unclear and requires further creative study.

The direct proximity of phosphorus with silicon and carbon in the Periodic System of D. I. Mendeleyev gives rise to many scientific comparisons and questions. By today the tremendous scope of synthetic, physical-chemical, industrial and biological works on the chemistry of phosphorus has reached such a theoretical and methodological level that the American chemist Van Weser, in his two-volume monograph, "Phosphorus and Its Compounds," suggested that the chemistry of phosphorus be singled out into a separate scientific discipline, similar to the chemistry of carbon [1].

Finally, it must be noted that in Kazakhstan, in the post-October period, several deposits of natural phosphates were discovered, the largest of which are the Middle Cambrian deposits in the Karatau Mountains. Discovered long ago, but not utilized until recent times, are deposits of phosphorites in the regions of Aktyubinsk and certain other regions.

Here it would be appropriate to say that almost all the natural phosphates extracted in the USSR and now being utilized were discovered and studied in the Soviet period. It is impossible to discuss the multi-faceted and exceptionally interesting history of phosphorus and its compounds, beginning with medieval alchemy and continuing to our times, in this survey report, since its task is to look into the future and shed light on the principal problems facing the chemistry and technology of phosphorus and its compounds. Given below are the most important inorganic and organic phosphorus compounds:

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Most Important Inorganic Phosphorus Compounds

PH_3--phosphine
P_2H_4--diphosphine
P H --lower hydrides of phosphorus (x>y)
$P_4O_6(P_2O_3)$, $P_4O_{10}(P_2O_5)$--phosphorus oxides
$H-P(OH)_2$--hypophosphorous acid
$P(OH)_3$--phosphorous acid
HPO_3--metaphosphoric acid
H_3PO_4--orthophosphoric acid
$H_4P_2O_7$--pyrophosphoric acid
$H_{n+2}P_nO_{3n+1}$--polyphosphoric acid
($H_5P_3O_{10}$--tripolyphosphoric, $H_6P_4O_{13}$--tetrapolyphosphoric and other acids
PX_3, PX_5, POX_3, PSX_3--halogenides and oxy(thio)halogenides of phosphorus (X=F, Cl, Br)
P_4S_n--phosphorus sulfide (P_4S_3, P_4S_5, P_4S_7, P_4S_9, P_4, S_{11})
$(PNCl_2)_n$--phosphonitryl chlorides (n=3-7)
$O=P(NH_2)_3$--orthophosphoric acid amides
P_nN_m--phosphorus nitrides (N:P=0.9-1.7)
Salts of phosphoric and polyphosphoric acids

Most Important Organic Phosphorus Compounds

Derivatives of hydrogen phosphide

RPH_2, R_2PH, R_3P--phosphines: primary, secondary, tertiary
R_2P-PR_2--diphosphines; phosphine, thiophosphine oxides; phosphonium compounds; phosphazo compounds, etc.

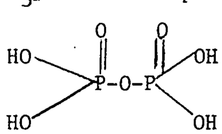
Derivatives of trivalent phosphorus acids

$R(OH)_3$--phosphorous acid, monoalkyl(aryl)phosphites, dialkyl(aryl)phosphites, trialkyl(aryl)phosphites, thio ethers, anhydrides, ether halogen anhydrides, etc.
$R-P(OH)_2$--phosphonous acid } Halogen anhydrides, ethers, thio ethers,
$R_2-P(OH)$--phosphonous acid } amides, anhydrides

Derivatives of pentavalent phosphorus acids

$O=P(OH)_3$--orthophosphoric acid, mono-, di-, trialkyl(aryl)phosphates, thiophosphates, ether halogen anhydrides, ether amides, etc.
$P(C_6H_5)_5$, $P(OC_6H_5)_5$--phosphoranes

$R_3P=N-R$--iminophosphoranes, or phosphazo compounds



--pyrophosphoric acid, tetraalkyl(aryl)pyrophosphates, thiophosphates, etc.

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$RP(=O)-(OH)_2$--phosphonic acid $R_2P(=O)-OH$--phosphonic acid	Halogen anhydrides, ethers, anhydrides, amides for both acids and ether halogen anhydrides, ether amides for phosphonic acid

The main directions in the use of compounds containing phosphorus are the following: fertilizers, fodder and food agents, agents to protect plants and animals (insecticides, fungicides, herbicides, etc.), medicines, catalysts, polymeric materials, plasticizers and stabilizers for polymers, hydraulic fluids, lubricants, surfactants, fireproofing devices--fireproofing compounds, corrosion inhibitors, incendiary and smoke-forming substances, semi-conductor and laser materials, glass with special properties, etc.

Raw Material Resources

Permit me to begin with a brief elucidation of the present level of study of the natural resources of phosphorus.

In the earth's crust phosphorus is contained in over 170 minerals, varying in their origin, concentration of phosphorus, composition of accompanying compounds and thickness of the deposits. To obtain phosphorus, phosphoric acids, fertilizers, fodder substances and commercial products, industry mainly uses phosphorites and apatites, which constitute 95 percent of the total amount of natural phosphorus-containing raw material extracted. Guano, phosphal and vivianite (iron phosphate) are used in negligible amounts. Up to the second half of the nineteenth century, industry and agriculture used mainly animal bones. Phosphorites are known in the deposits of almost all the geological systems--from the Precambrian to the Pliocene. Many of them are distinguished by heightened radioactivity [2].

The largest phosphorite deposits are in North Africa--their geological resources constitute 41 billion tons--in North America--14 billion tons--and in the USSR--about 16 billion tons (see diagram) [3]. Although the total number of deposits in the world exceeds 250, many of them have shallow or medium reserves, containing a low percentage of phosphorus and many undesirable impurities, which makes their economic utilization difficult. In the last few years new deposits have been discovered in the Western Sahara, Togo, Syria, China, India, Vietnam, Brazilia and a number of other countries. Unique magmatic deposits of apatite-nepheline ores, discovered in the Soviet Union in 1925 at Khibiny, on the Kol'skiy Peninsula, acquired worldwide renown. When these ores were concentrated, apatite concentrate was obtained with a content of 39.4 percent P_2O_5.* [4].

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*The exception is the concentrates of enriched phosphorites of the Pacific Ocean Island of Naura, which contain 42.5 percent P_2O_5.

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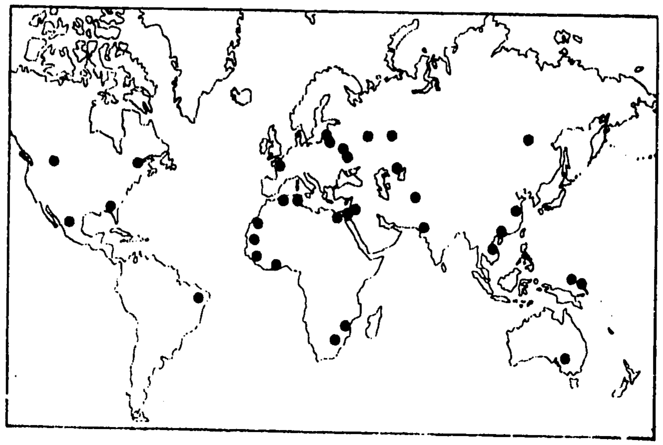
As a result, for several decades less attention was paid to the lean phosphorites known at that time.



Distribution of Main Deposits of Phosphate Raw Material in the World

In 1936 a second large raw material base was discovered in the USSR--geosynclinal phosphorites of the powerful Middle Cambrian Age in Karatau (Southern Kazakhstan). The principal phosphorite resources of Kazakhstan (the Karatau basin and Aktyubinsk group) constitute 30 percent, and the rest of the phosphate deposits in the European and Asian parts of the USSR --approximately 30 percent of the all-union resources. Included among the latter are deposits in the central regions of the USSR (Yegor'yevskoye, Vyatsko-Kamskoye and others), in the Baltic basin (Maardu, Toolse, Kingisepp and others), in Siberia--in Krasnoyarskiy Kray, in Gornaya Shoriya (Belkinskoye), in the Aldan River basin (Solikdarskoye), in Kemerovskaya Oblast (Tashtogol'skiy Rayon), in Buryatiya (Oshurkovskoye) and others. The figures mentioned will of course change with progress in geological prospecting work. Over two-thirds of the phosphates prospected in the USSR belong to the low-percentage group.

As a result of the geological studies of the last few years in the USSR a number of mineral deposits have been revealed, the ores of which contain apatite. In the process of their prospecting and concentrating, along with the basic mineral, apatite concentrate may be obtained that is suitable for chemical processing and contains from 30 to 40 percent P_2O_5. Among these deposits is the Yeno-Kovdorskoye, on the Kol'skiy Peninsula. Similar combined deposits were also discovered in Siberia--the Beloziminskoye, Kruchininskoye, Solikdarskoye, etc., and in the Urals--the Volkovskoye.

In view of the ever-increasing demand for phosphorus fertilizers of Siberia and the Far East and the still inadequate quantitative and qualitative

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provision of phosphate raw material for this huge eastern territory of the Soviet Union, the geochemists, geologists, concentration specialists and technologists, despite the progress achieved, continue to be faced with the pressing problem of expanding, intensifying and accelerating comprehensive research. There must also be intensification of the study of the perspectives for using phosphorus-containing iron ores, particularly of the eastern regions, for simultaneous obtaining of steel and phosphate slags, as well as comprehensive use of other ores and their associated minerals.

Indicative of the characteristics of the present-day importance of the problem of phosphate raw material are the predictive calculations of its world demand, made by American economists [5]. According to these calculations, the demand for phosphate raw material by the year 2000 will increase almost 4-fold as compared with 1970, and will be approximately 300 billion tons (for total weight); 93 percent of this amount is required by the fertilizer industry.

Selling prices for Florida phosphorites have almost quadrupled in three years (from 21.28 dollars per ton in 1972 to 47.50 dollars in 1974) [6]. Export prices for a ton of phosphorites from Morocco in 1974 rose from 42 to 63 dollars (P_2O_5 content--34 percent). With acidic methods of processing natural phosphates for fertilizer, the value of the raw material constitutes approximately three-fourths of the total production cost. Therefore, the problems of improving and reducing the expense of the processes of extraction and concentration of phosphate ores are very urgent ones. Unfortunately, in the study of the processes of concentrating phosphorites, until recently little use was made of chemical methods (use of acids, organic and other reagents) and their combination with physical and new technical devices. This work is now being successfully developed.

The largest and most upsetting problem of phosphorus raw material on the long-range plane is its limited natural resources, as well as the slow cycle of phosphorus compounds in nature and its great dispersion in the earth's crust and waters of the sea.

Rough summaries of the analytical data on the composition of the earth's crust (so-called clarkes) indicate that it contains approximately 32-fold less phosphorus than silicon, sodium and magnesium. The phosphorus resources detected and studied in the earth's crust up to recently are estimated at approximately $8.7 \cdot 10^{10}$ tons (not counting dispersed phosphorus) [7]. Up until the last few years deposits of phosphate ores with a content of phosphorus pentoxide lower than 10-12 percent were regarded as unsuitable for the production of superphosphate and wet-process phosphoric acid, but now they are beginning to use ores with a content of 3-4 percent P_2O_5. In a number of countries, including the USSR, the deposits for the most part are lean, requiring more complex technical and consequently more expensive processing methods.

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Considering the growth of the world population and the rapid development of chemization of agriculture--the chief consumer of phosphorus fertilizers, fodder agents and phosphorus-containing plant protection agents--the resources of mineral phosphates studied up to the present can provide for the demand for them as raw material for only 40-50 years in some countries, and in others (a few) for 200 years and more. A number of deposits also exist that, with the present-day scale of utilization, may be exhausted in 15-25 years. Many countries have no phosphate deposits at all. Hence a problem of global importance arises: how to provide the next generations of people with phosphorus, and in some regions-- our contemporaries.

In addition to the intensified development of geological prospecting, an improvement in industrial methods of extracting phosphorus from lean ores, from sea water and bottom deposits [8] (according to the estimates of M. V. Fedoseyev and V. V. Mokiyevska, the total amount of phosphates accumulated in the ocean waters is $(67-84)\cdot 10^9$ tons) and the use of the wastes of industry, rural and municipal services, in the future, physicists and chemists will probably raise the question (so far still unclear) of obtaining phosphorus by converting elements through decomposition energy and synthesis of atomic nuclei.

In connection with the limited nature of the natural resources of phosphorus, the problem becomes acute of considerably increasing the coefficient of the useful effect of phosphorus products, particularly fertilizers containing phosphorus, and of the degree of removing phosphorus in their extraction, concentration and chemical processing of ores. If, to the considerable losses accompanying these processes, one adds the losses of phosphorus in agriculture as the result of binding phosphorus in unassimilable compounds, as well as the losses in storage, transport and application to the soil, the total degree of use of natural phosphorus resources is approximately 40-60 percent. Agrochemical research on methods of raising the degree of utilizing phosphorus fertilizers is very urgent.* This problem is a global one. Finally, in the planned economy of the socialist countries these two problems can and should be solved more quickly and efficiently through the collective efforts of the chemists, in conjunction with the technicians, biologists, economists and other specialists.

The problem of raising the degree of utilization of natural resources of phosphates, of course, does not remove the need for widescale development of geological exploration and prospecting of new phosphate deposits, particularly in the regions not provided with raw material, as for example in

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* At the Department of Chemical Technology of Moscow University imeni M. V. Lomonosov and the Scientific Research Institute of Fertilizers and Insecto-fungicides in 1951-1954 phosphamide compounds were synthesized that were not bound by soil (S. I. Vol'fkovich, A. M. Malets, T. I. Sokolova); studies in this direction have been developed in the last few years at the SRIFI by A. S. Lenskiy and at MTU by L. V. Kubasova and others.

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Eastern Siberia, the Far East and other regions of the USSR, as well as the expansion of geological prospecting work in regions where the extraction of phosphates is already being carried out. The importance of these tasks is continually increasing because of the rapid development in the USSR in the last few years of the phosphorus-containing fertilizer industry.

Using Phosphates Insoluble and Slightly Soluble in Water

A problem of great importance for the further progress of agrochemistry and the technology of fertilizers is solving the question of the efficiency of phosphorus compounds that are slightly soluble in water. Studies and discussions in regard to the efficiency of using citrate-soluble phosphates in farming have an almost century-old history. Citrate-soluble phosphates are used efficiently in the agriculture of a number of countries--Thomas slag*, finely pulverized phosphorite meal, soluble in a 2-% citric acid solution, thermophosphates--products of the caking of phosphorites with soda or products of fusion with magnesium compounds and others, vivianite--iron phosphate $Fe_3(PO_4)_2 \cdot 8H_2O$, etc. Citrate-soluble phosphates are used in a number of countries mainly in acidic soils, along with using water-soluble phosphates, which have the advantage, with their local application to the soil, as top-dressings. In some countries, however, agriculture imposes a demand on the chemical industry--to supply fertilizers mainly in water-soluble forms. This demand is also imposed by many agrochemists in the USSR, despite the fact that as far back as the nineteenth century D. I. Mendeleyev and A. N. Engel'hardt, and in the twentieth century, D. N. Pryanishnikov, A. N. Lebedyantsev and others in numerous field experiments showed that finely pulverized phosphorite meal is highly effective on soddy-podzolic and broken-down leached chernozem soils, and remains effective for a number of years. D. I. Mendeleyev, in his time, wrote that in some experiments, careful pulverizing of the phosphates in the presence of organic and nitrogen substances made it possible to do without the use of acid.

Modern agrochemical studies have established the fact that pulverizing phosphorites of a certain type (mainly lumpy, sandy and clayey) are effective in acidic soils on a par with water-soluble fertilizers, and some--with application in doses-- 1.5-2-fold greater. The possibility of direct application of phosphorite meal is of practical importance for ores that are unsuitable for processing in water-soluble forms for basic application plowing. In many cases, phosphorite meal can have an advantage as a neutral fertilizer, not bound by the soils, and effective for several years. This question is critical both with respect to water-soluble uniform and complex fertilizers containing some phosphorus in the composition of insoluble compounds of iron, aluminum, calcium, etc.

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* Successfully used in the GDR, FRG, France, England, Belgium and other countries.

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The Decree of the CPSU Central Committee and the USSR Council of Ministers "On Measures for Further Development of the Agriculture of the Nonchernozem Zone of the RSFSR,"* intensifies the importance of the problem of using phosphates that are insoluble in water, but soluble in weak acids and are assimilable in soils that have actual, potential and exchange acidity.

In the last few years, in the USSR and certain other countries, processes have been developed to treat phosphorites and apatites with steam at a high temperature (1250-1500°), as the result of which the fluorine is removed and the phosphate passes into a form assimilable by plants and animals. For this purpose natural phosphate is subjected to processing by gases obtained from the combustion of natural gas. The products of this so-called hydrothermal method of producing defluorinated phosphates have been used until recently mainly as an efficient supplementary feeding for animals. The defluorinated phosphate is the cheapest fodder agent, considerably increasing the gain in milk, meat, coat, and making the animals healthier.** The production of defluorinated phosphates does not require considerable amounts of acids or alkalis and electric energy. Some 400 field experiments carried out in the USSR in 15 years on using defluorinated phosphates in all types of soils and for various agricultural crops showed that this type of phosphates, containing mainly tricalcium phosphate, gives a similar increase in harvest yield per weight unit of phosphorus as superphosphate, and for some crops improves their quality [9-13].

During the last few years various countries have been conducting experiments with elemental phosphorus as a source of plant nutrition. In vegetation and field experiments, noncombustible and nontoxic red phosphorus has been used with an admixture of a catalyst (salts of copper, iodine, etc.), which accelerates the transfer of the phosphorus into phosphoric acid compounds. The experiments conducted in the USSR (at NIUIF) by A. V. Sokolov, N. D. Talanov and K. F. Gladkova [14] and others, indicated that red phosphorus may be acidified in the soil and serve as a plant nutrient. Its expensiveness, however, caused by the length and difficulty of processing white phosphorus into red, requires a considerable improvement in the industrial processes both for obtaining elemental phosphorus through its reduction and sublimation from natural phosphates and for converting it into the red (polymeric) variant.

Phosphorus is now being obtained in the USSR and a number of other countries in electric furnaces with a power of up to 72,000-98,000 kilowatts, and the task is posed of achieving capacities of 150,000 kilowatts. Up to 12-14 kilowatt-hours of electric power are spent to obtain 1 ton of phosphorus from phosphorites. The cost of one ton of so-called thermal phosphoric acid obtained from elemental phosphorus, under today's economic conditions, is considerably more expensive than 1 ton of wet-process phosphoric acid,

* PRAVDA, 3 April 1974.

** This process was developed at the NIUIF, MGU and Tekhnoenergokhimprom, and was put into operation at four plants.

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obtained as the result of breaking down the phosphates in sulfuric acid. Thermal phosphoric acid, however, is much purer and more concentrated when obtained than wet-process phosphoric acid. The electrothermal process makes it possible to obtain, relatively easily, phosphorus anhydride and polyphosphoric acids, containing up to 85 percent P_2O_5, as well as to process phosphates of any composition and concentration of phosphorus (with, of course, varying energy expenditure). Under today's conditions the problem of reducing electric energy consumption for phosphorus sublimation is an urgent one. With a view to this studies and production tests are being made for partial or complete replacement of electric energy with the energy from burning natural or commercial gas.

The use of the heat from the phosphorus oxidation process and heat from the exhaust gases from furnaces has been developed at new enterprises. There is also the problem of chemical utilization of carbon monoxide formed in a reaction furnace. Solving these industrial energy problems promises a perceptible improvement in the economics of producing phosphorus and phosphoric acids. A longer-range significance to these problems, being solved in Kazakhstan, stems from the fact that the use of combined electrothermal and gas (cyclone) units, of the so-called industrial energy method of processing phosphates, permits easier utilization of low-quality raw material than for the wet processes. Because of the reduction in quality of many natural phosphates, as they become depleted, the cost of the acid processes (mainly sulfuric- and nitric-acid) will rise and of the thermal processes--go down. Therefore, all these methods must be creatively improved. The series of experiments in thermal dissociation of phosphates in electric vacuum and plasma reactors, with the separation of P_2O_5, conducted by R. G. Aziyev and S. I. Vol'fkovich [15] are worthy of continuation, to solve the economic problems.

Since the interesting, but uncompleted studies of processes of oxidizing phosphorus by water in steam and liquid form under pressure, conducted before World War II by E. V. Britske, V. N. Ipat'yev, A. V. Frost and their associates, this work has so far not been renewed, even though it has long-range interest for the simultaneous production of phosphoric acids and hydrogen.

Because of the striving to bind phosphorus with nitrogen in a maximally concentrated form, research was done on the conditions of synthesis, structure and technical properties of the phosphorus nitrides PN and P_2N_5, and the potentials for their use as fertilizer and new commercial material. This work is being continued.

A substantial series of studies has been devoted to methods of obtaining and to the properties of phosphides of iron, aluminum, magnesium, zinc, boron and some transitional metals, alloys used in metallurgy and also for obtaining phosphorous hydrides and other compounds. Some phosphides have recently been used at production facilities for infusible semiconductors, electroluminescent compounds, photocells, quantum generators (lasers), etc.

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In this field of research on the structure and properties of phosphides, a great deal new is still expected for technology, including for three- and higher-component phosphides.

Phosphorus hydrides, oxides, halogenides (particularly chlorides, hydroxychlorides, fluorides and bromides), sulfides and compounds similar to them, as well as oxy-acids of phosphorus and their salts, compounds of phosphorus with aluminum, silicon, chromium and a number of rare elements, are not discussed in this essay, since they are being covered increasingly widely in the literature, by including immediate problems of scientific research and their practical use.

Researchers are also faced with many theoretical problems of further, intensified study of stereochemistry and the properties of phosphorus compounds, particularly coordinational ones.

Phase transformations and the material composition and crystal chemistry of phosphorites and apatites merit further minute studies. To improve the industrial processes, thermodynamic and kinetic studies of phosphorus compounds and the processes of their reaction with other substances should be continued.

When covering the subject of the various functions of phosphorus, and the fields of use, one must not fail to mention the highly useful role of the radioactive phosphorus ^{32}P in compounds and preparations tagged with this isotope in scientific and technical research [29].

Polyphosphates

In the field of the chemistry of inorganic phosphorus compounds, particular attention should be directed toward the sharply intensified studies of the processes of polymerization of phosphoric acids and salts. New works are of great interest from the theoretical and technical standpoint, despite the fact that, beginning in the nineteenth century, condensed (polymeric) phosphate drew a great deal of attention. The great progress in the last 20-30 years was achieved due to the progress in the chemistry of high-molecular and complex compounds, their synthesis and analysis. A particularly large role was played by the use of modern physical-chemical methods of study: X-ray phase analysis, nuclear magnetic resonance, infrared spectroscopy, chromatography, viscosimetry, cryoscopy, dialysis, isotopy and new methods of chemical analysis.

Although these methods made it possible to establish the structure and properties of numerous polyphosphates and polyphosphoric acids, many questions still remained inadequately studied, including the series of crystalline, amorphous, vitreous and oligomeric products of polycondensation and polymerization, the optimal conditions for obtaining and altering their properties (solubility, fusibility, decomposition, capacity for chelation, etc.). Differences of opinion and contradictions still exist

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on questions of the conditions for obtaining certain linear, cyclical, ramified and combined polyphosphates, and even in their terminology.* These problems are covered in the well-known two-volume work by Van Weser and in the monograph by Ye. A. Prodan, and other works [16].

Polyphosphates have attained large and varied use in the production of cleaning agents and detergents (mainly sodium and potassium tripolyphosphates), additives to certain food products (fusion of cheese, sausage, etc.), to soften water, as flotation agents, in the production of cellulose, paper, textile, rubber and leather materials, corrosion inhibitors, the components of some medicinal and cosmetic preparations and many others. This variety of the spheres of application is due to the numerous properties of polyphosphates: complexing, condensing, structuring, suspending, emulsifying, stabilizing, plasticizing, water-softening, oxidation inhibiting, froth-forming, corrosion inhibiting, etc.

During the last few decades there has been increasing use of phosphoric acids, phosphates and polyphosphates as binding materials, possessing adhesive properties and ensuring, in compositions with other inorganic and organic substances, heat-resistance, fire-resistance, mechanical strength, corrosion resistance and other qualities [17, 18]. As the result of the polycondensation of the binders during heating, a reaction occurs with the "fillers" (silicates, clays, chromium, zinc and many other materials), and so-called phosphate cements, ceramic and other materials are obtained. Phosphate glass, fiber glass and enamels with special properties are also well-known. Phosphates are successfully used in lasers.

The group of commercial phosphates making it possible to glue and bond various materials--metals, silicates, ceramics, wood and others--is of advanced significance for the construction, metallurgical, electrical equipment and other sectors of industry. Modern research in this field, which utilizes the progress in physical-chemical mechanics, crystal chemistry and solid state physics, is directed toward the further development of the most economical compounds of phosphates and other substances.

At a number of scientific institutes of the USSR Academy of Sciences and the republic academies of sciences, ministries and VUZ's in the USSR, as well as in other countries, in the past few years polyphosphates of ammonia, potassium, sodium, magnesium, carbamide and organic compounds have been studied and introduced into production, as well as amide- and imidophosphates (as efficient fertilizers), and some of them--also as fodder supplements in livestock breeding. Polyphosphate fertilizers are the most highly concentrated and have a slow, but consequently longer action, higher degree of phosphorus utilization, reduced quality of binding with soils (retrogradation), good physical-mechanical properties and other qualities. Their complex-forming and ion-exchange properties should also be noted.

* So far, along with the chemical classification and terminology in the literature, obsolete names of high-polymer salts, named after researchers, are used, as for example, Grem, Kurrol, Madrell salts, and others.

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The polyphosphates of carbamide and compounds of ammonium phosphates with carbamide and potassium salt (called "karbammophoska" in our country) are of great interest for the future [19-22].

Phosphorus-containing fertilizers, alkylated derivatives of phosphorus amides (alkylphosphates), available and only weakly retrogradive in soils, and considerably surpassing the efficiency of orthophosphates in sierozem soils, are very interesting. Also of long-range importance are the processes for producing potassium and ammonium polymetaphosphates. Potassium polymetaphosphates are 100-percent complex, chlorine-free fertilizers, with excellent physical properties, and may be obtained with varying solubility and with a varying ratio of phosphorus and potassium [23-26]. Ammonium polyphosphates are distinguished by high efficiency as highly concentrated fertilizers (a content of up to 75-80 percent nitrogen and phosphorus pentoxide). Superphosphates are also of interest.

Mention deserves to be made of the use of polyphosphates in the nuclear industry as additives to agents for cleaning the surface of equipment and clothing of traces of many elements and deactivating radioactive residues (particularly strontium, calcium, etc.) [27, 28].

Organophosphorus Compounds

In passing to the subject of organophosphorus compounds, it should be recalled that with respect to the number of synthesized compounds they are a thousand times greater than the inorganic, and the total content by weight of phosphorus in organic compounds is hundreds of times less. The scientific and national economic importance of organophosphorus compounds is tremendous, and is rapidly growing in the fields of biology, medicine and agriculture. The range of their use in technology and biology is continually expanding.

The use of organophosphorus compounds began earlier in technology than in biology. Among the technologically important products are solvents, plasticizers and condensing agents, in plastics production; flotation agents for ore-concentration; additives for lubricants, increasing their rheological and corrosion-inhibiting properties at various temperatures and pressures. A valuable property of plastics obtained from unsaturated phosphorus-containing compounds (as well as a number of inorganic phosphorus compounds) is their complete incombustibility or reduced ignitability, which makes it possible to use some of them as fireproofing compounds for fireproofing wooden, textile and other materials. Selective organophosphorus extractants have become very important in the technology of rare and radioactive elements [30].

The present-day state and problems of science and technology in these fields of the chemistry of organophosphorus compounds is relatively well covered in a number of books and journal surveys, so we will restrict our discussion here only to a mention of them [31, 32].

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Research done by physical chemists and biochemists in the last quarter of a century achieved great progress in the field of the synthesis, analysis, structure and physiological functions of complex organophosphorus compounds. The synthesis of organophosphorus compounds, begun 130 years ago by L. Tenar, was not systematically developed until the end of the nineteenth and beginning of the twentieth century. D. I. Mendeleyev, in "Fundamentals of Chemistry" noted a number of important but unexplored theoretical problems of the organic chemistry of phosphorus compounds. A. Ye. Arbuzov, in one of his works, mentions that it was these propositions of D. I. Mendeleyev that instigated the beginning of his systematic study of organophosphorus compounds, to which he and his school devoted over half a century of creative work.

Included among the fundamental works on organophosphorus compounds are the studies of chemists from our country: N. A. Menshutkin, Ye. Ye. Vagner, G. M. Kosolapov, A. Ye. and B. A. Arbuzov, V. M. Plets, T. A. Mastryukova, A. V. Kirsanov, A. N. Pudovik, N. N. Mel'nikov, I. F. Lutsenko, E. Ye. Nifant'yev, N. N. Godovikov, K. A. Petrov and others, and in foreign countries--H. Hofman, A. Mikhailis, R. Schrader, A. Todd, A. Frank, G. Van Weser, D. Braun, K. Suenag, A. Cotter and other scientists. These studies laid the foundation of the large, tall building of the chemistry of organophosphorus compounds, which has grown in the last few decades in a number of countries, and is rapidly being filled with creative scientific and practical content. The number and variety of organophosphorus compounds synthesized and studied in laboratories are now calculated in tens of thousands, and those produced in industry--in hundreds.

The many-faceted interest in organophosphorus compounds on the part of chemists and biologists is so great that at special international and domestic conferences and symposiums, convened every year, hundreds of papers and reports on new work are delivered.

In the last 30-40 years the extremely important role of organic and inorganic phosphoric acids in the life of animals, plants and microorganisms has been revealed and studied. Their role is diverse, particularly in the metabolic processes--catabolism and anabolism; in the processes of glycolysis and the breakdown of hydrocarbons, photosynthesis and chemosynthesis in cells [33-35]. As is known, phosphorus is included in the composition of nucleinic acids, nucleoproteins, phosphamides, saccharophosphates and also a number of vitamins and enzymes. Organic compounds of phosphorus participate in many oxidation-reduction reactions, in the processes of carboxylation and decarboxylation, acetylation, transamination and also as coenzymes in the transfer of phosphorus groups of adenosine triphosphoric (ATF), adenosine diphosphoric (ADF) and adenosine monophosphoric (AMF) acids.

The revelation of the role of organophosphorus compounds in the transmission of neural stimuli was an important discovery in the twentieth century. Another great event in biochemistry and physiology was the discovery by W. A. Engelhardt of the mechanism of oxidizing phosphorization in the

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respiratory processes of the cell, accompanied by the conversion of inorganic phosphate into an organic phosphate derivative--adenosine triphosphoric acid. Later on, in conjunction with M. N. Lyubimova, he established the energy role of ATF in the functioning of human and animal muscles [36]. In the last few years valuable research in bioenergetics--the molecular generators of electric current--was performed by V. P. Skulachev, Ye. A. Liberman, L. M. Tsofina and A. A. Shaytis. Many processes in organisms take place by means of organophosphorus compounds, particularly phosphorus proteins and nucleinic acids. As early as 1945, W. A. Engelhardt wrote [37] that the biochemical dynamics of the cell may be characterized as the chemistry of compounds of phosphoric acid. Scientific progress is continually giving us increasingly new cases and proofs of the participation of phosphorus compounds in the vital life processes.

Problems of the energetics and metabolism of organophosphorus compounds in the life of animals and plants have not yet been fully disclosed, and in the light of today's tasks of molecular biology and bionics, deserve further thorough and precise studies.

It is widely known that many organophosphorus compounds, such as medications, insectofungicides, herbicides, stimulants, mutagens, sterilants and many other substances have a strong physiological action that affects the vital activity of organisms, as well as their participation in the construction of molecules of nucleinic acids, some vitamins, enzymes and hormones. Some phosphate coenzymes play the role of intermediary transmitters (acceptors and donors) of certain chemical groupings, as well as of electrons and atoms of hydrogen. For example, nucleotide transferase, which catalyzes this process, is among the carriers of nucleide residues containing phosphoric acid.

It can be said without exaggeration that in metabolism, in the phenomena of heredity and in the evolution of the development of organisms, organic and inorganic phosphorus-containing compounds play an extremely varied role, as yet insufficiently revealed. The further development of work in the field of the synthesis, analysis and physical-chemical research at the juncture of various fields of chemistry and biology is also substantial and drawing attention.

The most general analysis of modern development and progress in the chemistry of organic compounds of phosphorus [38-40] attests to the fact that, despite the major achievements in science and practical work, researchers are still faced with many important tasks in broadening and deepening our concepts in the sphere of physiology, toxicology, pharmacology, medicine and agriculture, in the theoretical study of the conformances to principle that relate their composition, structure and properties, and also in seeking new production processes and improving the existing ones, including the problem of raw material, labor safety and environmental protection.

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Using Compounds Containing Phosphorus in Medicine and Chemical Protection of Plants and Animals

Progress in synthesizing and analyzing afforded the opportunity, at the beginning of the twentieth century, of using compounds containing phosphorus in medicine, veterinary science and chemical protection of plants and animals. In the twentieth century there was exceptionally widescale, comprehensive and rapid development of work in studying and using insectofungicides, herbicides and other bioactive agents in plant growing, and, more slowly--in livestock breeding. New medications underwent prolonged testing due to the need for detailed and multifaceted evaluation of their physiological effect and consequences for man, domesticated animals and insects.

Some of the first preparations used in medicine were calcium, sodium and magnesium phosphates, glycerophosphate, leucitine, products of adenile acid and, widely used in the last few years, adenosine triphosphoric acid (ATF). These preparations are used as tonics, vasodilators, stimulants of cardial activity and hemopoiesis, in anemia, rickets, osteomalacia, tuberculosis and a number of nervous diseases. The organophosphorus preparations used against glaucoma are widely known: phosarbine,* phosphacol, armine and other preparations, developed by A. Ye. Arbuzov.

Clinical studies also indicated the efficiency of using a number of organophosphorus preparations against mental diseases, traumatic paralysis and intestinal atony, to accelerate the labor process, and for other purposes. Some compounds containing phosphorus that suppress choline esterase broaden the perspective for affecting the central nervous system and functions of the cerebral cortex.

Comprehensive research on medicines, with respect to the nature of the study, approximate work on chemical agents to protect plants and animals: insectofungicides, acoricides, herbicides, defoliants, helminthocides and other veterinary agents. Among the many hundreds of these agents, one of the leading roles is played by phosphorus compounds, the world assortment of which is close to 150 preparations, and is continually growing. Their success is due to the high efficiency in a variety of spheres of application, comparative economical nature, rapidity of decomposition in most organisms, in soils and waters, with the formation of compounds that are nontoxic, or only slightly toxic, to man, domestic animals and insects, as well as to the lack of an ability to accumulate in organisms.

Biochemical studies indicate that organophosphorus preparations that correspond to Schrader's formula inhibit choline esterase relatively rapidly. Mainly used to protect plants are derivatives of phosphoric, thio- and dithiophosphoric and phosphoric acids [41-44]. A good effect in the quality of the insecticides and acaricides was shown by alkylphosphates and amides of fluorophosphoric acids. It is interesting to note that

* Tetraethylmonothiopyrophosphate.

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substituting one of the oxygen atoms for sulfur in derivatives of phosphoric acid considerably reduces the harmful effect of these compounds on man and animals, while retaining the necessary pesticidal activity. Some compounds (particularly ethers of phosphorous acid) are efficient weed killers.

The variety and number of organophosphorus compounds that are important in protecting plants and animals is so great that in the monograph by N. N. Mel'nikov, "The Chemistry and Technology of Pesticides," the tables listing them take up 24 pages.

The research and studies of new phosphorus-containing medicinal, pesticidal and other bioactive agents, developed recently, are directed toward studying the conformances to principle that join together their composition, structure and biochemical and physical-chemical properties. An example of this scientific work, uniting chemists and biologists, is the comprehensive study by M. I. Kabachnik, M. Ya. Mikhel'son and their associates, who established the relationship between the composition, structure and mechanism of the toxic effect of organophosphorus compounds on various physiological processes. A thorough study of the mechanism of the physiological action of organophosphorus insecticides and acaricides makes it possible to create new preparations with selective action, and to reveal their structure.

The biochemical studies on the molecular level made by F. Krik, Kh. G. Korana, A. S. Spirin and others open great perspectives in the field of the structure and functions of organophosphorus compounds in proteins, nucleinic acids and other objects.

It should be hoped that empirical research and screening of new physiologically active substances will be increasingly substituted for theoretical prognoses.*

When speaking of pesticides and other toxic substances, one must not fail to mention ways of protecting man and the environment. In our time these vital questions should mainly be solved through prophylactic measures, with the development of production processes and application, and not by rendering poisonous products harmless after their use or with careless use of them. Despite the high efficiency of a number of organophosphorus preparations, shortcomings are inherent in many of them that force chemists and biologists to seek new agents to protect plants and animals. Therefore, scientific boards of experts and plans specify: intensification of work on seeking not only synthetic, but also microbiological agents that are harmless for man and animals; the use of integration measures, combining chemical, biological, agro- and zootechnical agents, and also methods such as granulation and capsulization of solid preparations and others. Despite the great progress in the production and use of organophosphorus compounds, chemists,

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* A center was recently organized in the USSR to test newly synthesized bioactive compounds.

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technologists, toxicologists and other specialists are still faced with many complex problems, the solution to which requires thorough and precise research. The problem is being solved of their syntheses with the medium not only of phosphoric chlorides and sulfides, but also of elemental phosphorus, phosphorus trioxide and other initial compounds of phosphorus. It is probably useful for toxicologists and physiologists to have a deeper acquaintance with the results of research in molecular biology and enzymology, and to make broader use of the newest physical and physical-chemical methods of studying the structure and properties of bioactive compounds.

Conclusion

From the brief survey given it can be seen what a large number of various phosphorus-containing substances are being thoroughly studied and used and merit further purposeful comprehensive research. There can be no doubt that the bridges being built between chemistry, biology and technology, between inorganic, organic and physical chemistry of phosphorus and between theory and practice will ensure new creative achievements, intensify the feedback among various sectors of science and raise even higher the importance of phosphorus for life and for social and cultural progress. It is good that the chemists of the Soviet Union, in cooperation with the scientists of other countries in the world, are taking a worthy, creative part in the tremendous, fruitful international work.

The first part of this survey emphasized the limited nature of the natural resources of phosphorus and the low degree of their use in today's basic chemical industry, agriculture and other major sectors of the national economy, which raises great, complex problems for geologists, chemists, biologists and specialists in various sectors of technology. We are obliged to deepen the theory purposefully, in accordance with the plan, to intensify research and to accelerate putting the scientific achievements into effect in the national economy and public health, taking into consideration environmental protection, the economics of production and the use of compounds containing phosphorus.

In concluding the report, I feel the need to recall the fact that 1975 marked the 50th anniversary of the discovery in the Soviet Union of the extremely large deposits of apatite ores in Khibiny, which was a historic landmark in establishing the powerful domestic phosphate industry. This discovery and rapid development of these ores in the unpopulated polar regions, which was the collective achievement of specialists in various fields of science and technology--geologists, chemists, engineers, agrochemists, economists, etc.--inscribed bright pages in the history of the building of socialism in our country and became the beginning of a new era in creating the powerful phosphate industry and in chemization of agriculture in the Soviet Union. It is also appropriate to mention that 1976 marked the 40th anniversary of the discovery of the second powerful raw materials base of the phosphate industry--the Karatau deposits.

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Recalling these significant dates and surging flow of research on the chemistry of phosphorus, there can be no doubt that the scientists and production workers will also in the future work on the study and optimum use of phosphorus, so that this "light-carrier" and "life element" may contribute to the further rise in health and well-being of the people, nourish and strengthen their powers, create new materials and make a creative contribution to the progress and flourishing of human society.

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RADIATION CHEMISTRY

UDC: 541.15

CHEMICAL PROTECTION OF ORGANIC SYSTEMS AGAINST IONIZING RADIATION

Moscow KHIMICHESKAYA ZASHCHITA ORGANICHESKIKH SISTEM OT IONIZIRUYUSHCHEGO IZLUCHENIYA (Chemical Protection of Organic Systems Against Ionizing Radiation) in Russian 1978 signed to press 2 Aug 77 pp 2, 141

[Annotation and table of contents from book by Mikhail Fedorovich Romantsev, Atomizdat, 1550 copies, 144 pages]

[Text] Enhancement of radioresistance of rubber, oils and lubricants, organic coolants and other materials by means of special chemical additives (antirads) opens up new possibilities for the use of such materials in the atomic industry, in space and in cases where the materials may be exposed to ionizing radiation.

This book sheds light, on the basis of published data and studies of the author, on the current status of chemical protection of organic systems against ionizing radiation; it discusses the mechanism and kinetic patterns of action of antirads, suitability of different substances as protective supplements and possible approaches to solving the problem of chemical protection.

There is comprehensive coverage of questions of practical use of antirads to stabilize lubricants, elastomers, polymers, coolants, fuels, dyes and other systems.

This book is intended for specialists in the field of radiation chemistry, radiation materials technology and different fields related to the use of atomic energy.

There are 44 illustrations and 69 tables; bibliography lists 259 items.

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PLANT SAFETY

UDC: (661.7/19)004.58

SAFETY RULES FOR PLANTS PRODUCING ORGANIC CHEMICAL REAGENTS

Moscow PRAVILA BEZOPASNOSTI DLYA PROIZVODSTV ORGANICHESKIKH KHIMICHESKIKH REAKTIVOV (Safety Rules in Organic Chemical Reagent Industries) in Russian 1978 signed to press 6 Jun 78 pp 2, 74-75

[Annotation and table of contents from book edited by Yu. N. Slesarev et al. (Gosgortekhnadzor SSSR [State Committee of the USSR Council of Ministers for Supervision of Industrial Safety and for Mining Inspection]), Izdatel'stvo Nedra, 6600 copies, 76 pages]

[Text] These rules define the safety requirements for organic chemical reagent plants that are being designed, under construction, remodeling and in operation. In addition to general requirements, there are safety requirements for individual chemical processes. The specifications are spelled out for each type of production with regard to outfitting with monitoring and measuring instruments, automatic control systems, protective devices, blocks [interlocks], cut-offs and signal systems. There is discussion of requirements referable to territory, buildings and installations, transport routes and roads, arrangement of equipment and work places. Attention is given to fire-control measures and personnel protective devices for workers.

These rules are intended for all engineering and technical workers concerned with design, assembly, remodeling and operation of organic chemical reagent plants.

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WATER TREATMENT

WATER TREATMENT BY REVERSE OSMOSIS AND ULTRAFILTRATION

Moscow OBRABOTKA VODY OBRATNOM OSMOSOM I UL'TRAFIL'TRATSIYEY in Russian 1978 signed to press 13 April 1978 p 2, inside front cover

[Annotation and table of contents from book by A. A. Yasminov, A. K. Orlov, F. N. Karelin and Y. D. Rapoport, Stroyizdat, 5000 copies, 121 pp]

[Text] This book discusses problems of the preparation of natural and purified waste waters by means of semipermeable membranes, as well as describing the properties of the membranes and methods of preparing them. The designs and characteristics of membrane elements and apparatus are described, they are classified and an analysis of their technological parameters is given. Units using different processes are described, and design calculation methods and operating results are given. A technical and economic evaluation of membrane treatment of water is given.

The book is intended for scientific and engineering-technical workers in scientific research and planning organizations.

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