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Brief communications

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Chromatography in ecology

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The solution of the problem of ecology in all countries, namely the creation of waste-free technologies the utilisation of the materials obtained, the study of their metabolism under operating conditions, their regeneration, and their disposal, is impossible without chemical analysis of complex organic mixtures, which permits not only the determination of the overall content of the organic substance but also the establishment of the presence and the determination of the concentrations of specific mixture components. Chromatography combined with mass spectrometry, IR Fourier spectroscopy, UV spectroscopy, etc. has become such an analytical procedure.

Chromatography makes possible the selective determination of microimpurities at virtually any level, which is especially important in the solution of ecological problems. As a result of the chromatography of a mixture, the separated individual components pass to the instrument for their determination (mass spectrometer, IR Fourier spectrometer, etc.) and are then identified by spectroscopic methods. At the present time, all the leading and the majority of ordinary analytical laboratories abroad, engaged in the analysis of objects in the environment, are equipped with chromatograph-linked mass spectrometers and a large number of gas and liquid chromatographs.

The state of organic analysis in our country is extremely unsatisfactory: thus only one of each ten sanitary-epidemiological stations, i.e. the principal organ for the monitoring of the environment, is at present equipped with gas chromatographs and the number of liquid chromatographs is even smaller. We lag behind the USA by a factor of 5–6 as regards the manufacture of gas chromatographs and by a factor of 50–60 as regards liquid chromatographs. Chromatograph-linked mass spectrometers of modern design are not manufactured in the USSR and, according to our information, IR Fourier spectrometers, which might be used in combination with chromatographs, are not being developed either.

The foregoing shows that, for the successful solution of ecological problems, it is necessary to develop analysis and especially organic analysis on the basis of primarily chromatographic methods combined with mass spectrometry. For a rapid rectification of the existing situation, it is desirable to organise a methodological centre and regional analytical centres provided with modern equipment purchased abroad.

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Electrochemistry and protection of the environment

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There are many electrochemical aspects of the solution of ecological problems. In the first place, these include the creation of new industrial technologies, procedures for the purification of waste waters, and the development of sensors for the monitoring of the environment. Electrochemistry can also make a serious contribution to the creation of ecologically clean transport and power engineering.

A series of studies designed to protect the environment has been carried out in recent years at the Institute of Electrochemistry of the USSR Academy of Sciences. A procedure has been developed for the ultilisation of gas-absorption hydrochloric acid, which is a waste product of the large scale organochlorine synthesis in the electrochemical chlorination of ethylene to dichloroethane. This procedure is protected by patents. An experimental-industrial 5 kA apparatus has been constructed and tested jointly with the undertakings of the Ministry of Chemical Industry at the "Orgsintz" factory in Sumgaite. A technical requisition for a plan of an experimental works designed to produce 10000 tonnes of dichloroethane annually has been made. Unfortunately, the works has not so far been constructed and the contamination of the Caspian Sea continues.

The scientific principles of a low-waste industrial technology for the electrosynthesis of chemical additives to polymers are being developed. In particular, processes for the electrochchemical synthesis of sulphenamide M (a thiazole vulcanisation accelerator) and benazole P (a benzotriazole photostabiliser for polymers) have been developed. These make it possible to obtain high-quality products, to abandon the use of chemical oxidants, and to reduce sharply the amount of industrial waste. Both developments are being tested on an experimental-industrial plant at NIIKhIMPOLIMER (in Tambov).

On the basis of the results of fundamental research into electrocatalysis, a highly sensitive and rapid method for the analysis of organic impurities and heavy metals in water, which has no analogues in world practice, has been devised. The method is protected by USSR and Swiss patents. On the basis of this method, our Institute devised and constructed jointly with NIIKhIMMASh a series of analysers (AKVEL) which have been highly approved by specialists at International and All-Union Expositions. Their sensitivity is 0.01 mg litre^{-1} with respect to total organic carbon and 0.001 mg litre^{-1} with respect to heavy metals. The duration of analysis is 3–15 min. The weight of the apparatus is 1.5 kg and its size is 19 × 28 × 20 cm. the AKVEL analyser is not inferior to the best western analysers for total organic carbon as regards sensitivity and speed of action. At the same time, it is distinguished by simplicity of design, small size, and low cost.

An experimental batch of AKVEL analysers, used for the monitoring of especially pure deionised water and for the analysis of natural waters, has been produced recently. Studies are being prosecuted on the creation of a sensor for organic impurities which is extremely small and works in a stream of water using an ion-exchange membrane as the electrolyte.

Sensors for oxygen in liquid media, carbon dioxide, hydrogen sulphide, carbon monoxide, and hydrogen have been developed. The electrochemical sensors designed to determine the concentrations of sulphur dioxide and hydrogen sulphide, constructed jointly with the Automation Experimental Design Bureau "Khimavtomatika", have no analogues in world practice as regards electrochemical instrument making. Models of sensors for low and high concentrations have been developed. The nominal time for the establishment of readings is 30–40 s. The sensors are distinguished by a low level of the background signal and a high stability of the output signal and contain no precious metals. It is proposed that the sensors be used to monitor the atmosphere in sulphuric acid and other industries.

Several types of sensors for oxygen have been developed: amperometric sensors of the Clark type and sensors based on a new adsorption kinetic principle. The Clark type sensor with a membrane, for artificial blood circulation apparatus, is distinguished by the rapidity of response, high stability of readings, and very small size (miniaturisation). An experimental batch of such sensors has been produced recently by the Institute of Experimental and Clinical Surgery of the Ministry of Health of the Georgian SSR. Clinical tests have been carried out under operating conditions and permission for clinical application has been received. These sensors can be used successfully also for ecological purposes.

Studies are being prosecuted on an oxygen sensor of the open type (without a membrane) for use in liquid and gaseous media with a carbon material as the indicator electrode. The response requires several seconds. The range of pressures determined is 0–760 mmHg.

The sensor based on the adsorption kinetic principle has a number of advantages over those available previously. High speed of response (4 s), high sensitivity (10 mV per 1% of O_2), accuracy at the level of the best foreign devices (0.1–0.2%), and a significant reduction of the consumption of oxygen during analysis. The sensor can be used in gaseous, liquid, and biological media.

A selective catalyst for a carbon monoxide sensor, permitting the determination of CO concentrations in the presence of hydrogen, has been developed. The sensors, with an improved selectivity, have been constructed jointly with the Chirchiksk Automation Experimental Design Bureau and have been introduced at the Novo-Dzhambul'sk Phosphorus Works.

It is noteworthy that the electrochmeical methods are extremely effective in the creation of sensors for different individual substances. They are highly sensitive, respond rapidly, and can be used in automatic monitoring systems.

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Local monitoring. Organic materials — new possibilities for ecological monitoring

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The principal argument used by opponents of giving immediate priority to ecological problems is the lack of reliable quantitative data on the state and quality of the environment and about the immediate and remote ecological consequences (including man) of deviations from the ecological norm and concerning the very concept of the ecological norm. The primary aspect of the answers to all these questions is provided by the measurement of the set of parameters of the environment which is as complete as possible.

Ecological monitoring is divided into global, regional (at the level of continents, sub-continents, and countries and the trans-border transport of pollutants), territorial (industrial regions, cities, large agricultural-industrial complexes, dissipation of pollutants), and local (the vicinity of individual undertakings, emissions, waste, discharges, and the technosphere).

Each of the above types of monitoring has its own main task and its own set of measuring devices. However, the optimum provision of information-gathering devices for the control system at all the hierarchical levels can be achieved only by employing the entire set of data obtained by all types of monitoring, i.e. by means of a systemic approach.

Global, regional and territorial monitoring are carried out mainly by remote control methods — aerocosmic, laser, etc. The main limitation of the remote control methods is the generation of averaged information and appreciable difficulties in establishing a specific source of pollution of the environment or, more precisely, the determination of the centres of ecological breakdowns. However, the devices for remote control monitoring have been thoroughly developed during the last decades, a system of exchange of information within the limits of individual countries has been set up, and a system of international links is being gradually established.

The principal cause of the breakdown of ecological equilibrium is human activity, as a result of which local monitoring comes to the fore in the solution of problems of the rational control of ecological processes. However, local monitoring is in fact least adequately