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

provided with measuring devices. The existing measuring devices and sensors, mainly from the range of analytical instruments which were not initially designed for ecological purposes, are too cumbersome, expensive, and insufficiently selective for wide scale employment in practice. Furthermore, it is virtually impossible to achieve their unification as regards the output signal and thus to create an information-measuring system on their basis.

The creation of monitoring-measuring apparatus for local monitoring of the environment requires the involvement of devices produced by microelectronic instrument making, involving the use of adequate materials for the sensitive elements of sensors.

During the last decade, data have appeared in the scientific and patent literature concerning the effective use of organic semiconductors as materials for the sensitive elements of sensors designed to determine the composition of complex gas mixtures, including the real atmosphere.

The advantages of organic semiconductors are their high sensitivity and selectivity combined with a high resistance to breakdown including the poisoning effect of the accompanying impurities. Sensors for ammonia, phosphine, arsine, hydrogen sulphide, oxygen, and sulphur dioxide have already been developed on the basis of organic semiconductors (molecular charge-transfer complexes and conducting polymers as materials of the sensitive elements) and the possibility of constructing sensors for a number of other gaseous atmospheric pollutants has been investigated. The use of metal-containing phthalocyanines for the detection of hydrogen sulphide yielded best results, superior to the current world level.

These sensors, which operate even in a direct resistive regime, are distinguished by their small size, reliability, stability of operation under natural conditions, and the possibility of being manufactured by means of a standard planar microelectronic technology. Their main disadvantage is an inadequately rapid cyclic response in the interrogatory (discrete) regime of the operation of information-measuring systems incorporating such sensors. A further increase in the rapidity of response, the expansion of the range of measurement using a single sensor, miniaturisation, and the generation of a voltage signal without an intermediate amplifier involve the use of integrated hybrid sensitive elements combining in a single planar structure a transistor based on the traditional semiconductors and a sensor based on organic semiconductors.

One of the important conclusions reached in a theoretical study of the relation between the sensitivity and selectivity of the sensitive elements and the electronic structure of organic materials has been the conclusion that extensive purification or purification with subsequent deliberate doping of the materials of the detecting media is necessary, since the presence of non-controlled impurities makes the semiconductor non-intrinsic and always reduces the sensitivity and the threshold of the determination and frequently also the selectivity of the material of the sensitive element. Methods for the purification of organic semiconductors have now been developed at the Gorky State University. For the practical purpose of constructing information-measuring systems for local atmospheric monitoring, one of the consequences of this systemic approach is most important, namely, when two sensitive elements based on organic semiconductors have comparable but different sensitivities with respect to two atmospheric components being determined, the concentration and temperature dependences of their sensitivities are different for the two elements, which makes it possible to increase their selectivity appreciably by purely computer methods. This property of the sensitive elements in the sensors of the multiparameter system permits a reduction of the requirements which must be met by the material of each element and an increase in their effectiveness in the system. The earlier sensors are amplitude-modulated detectors. Their great advantage is their low intrinsic cost and ready susceptibility to technological operations, while their disadvantage is the need for additional schematic and technical solutions in computer systems for the collection and processing of information.

The enormous advantages of large information-measuring systems constructed using modern facilities provided by the computer technique arise from the application of frequency-modulated sensors. Thus an instrument for the measurement of the concentrations of atmospheric and technological oxygen has been developed on the basis of the long-lived diphenylpicrylhydrazyl radical in the core of a superheterodyne receiver exposed to the stream of gas.

Thus the materials developed within the framework of studies on the electronics of organic materials can provide a new elementary base for ecological instrument making, which will in its turn make it possible to create an effective local monitoring system. The creation of such a system will permit the adoption of well-founded solutions in controlling the operation of undertakings in order to rule out the pollution of the environment, and in the first place the atmosphere, on the state of which depends human health and man's very life.