FROM HOLLOW FIBRES TO MEMBRANE PLANTS

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Man-made fibres having internal channels of significant size which gives them the right to be called hollow conform to the obvious priorities which are characteristic of the contemporary development of membrane technology. Such fibres are used for practically all known membrane processes and have a number of important advantages over other forms of membranes; for example, those prepared in the form of asymmetric films [1, 2].

The technical-economic and social causation for the development of hollow fibres is primarily connected with an examination of them as an inherent part of membrane units for leading branches of the national economy, including such parts as medicine, electronics, the food industry, biotechnology, petroleum chemistry, space travel, etc. The organization of manufacture and use of hollow fibres of a wide assortment directly in the man-made fibre subbranch may become no less attractive. This has been dictated on one hand by the high profitability of manufacturing and the growing demand for the finished product and, on the other, by the application of membrane units directly in the chemical industry to clean up harmful discharges, create an inert medium, to dry air, for separation of gas mixtures and liquid mixtures, for regeneration of lubricants, and so forth.

According to the problems formulated above, studies are being carried out in the "Khimvolokno" NPO on the development and pilot-plant scale assimilation of technology for preparing hollow fibres and apparatus (modules) based on them for membrane separation by the most well-known procedures [3, 4]: reverse osmosis, ultrafiltration, or gas diffusion. Searches have been started in the region of spinning hollow man-made fibres from melts and solutions of polymers for nano- and microfiltration, liquid membranes, pervaporation, and so forth [5-7].

Now, as never before, it is appropriate to speak of priority development of membrane techniques. According to predictions of foreign specialists, the world sales volume of membranes, membrane elements and modules in 1990 is expected to be eight times as large as in 1985 at a mean tempo of growth of about 20% per year [8]. Thereupon, the USA market makes up 55% of the world market for membranes, membrane elements and modules, and 40% of the world market in membrane separation units; the market in Western Europe is 20% and 35%; in Japan, 22% and 10%; and in countries of the Third World (where the USSR, unfortunately, occupies a significant role in this region), 3% and 15%, respectively [9]. For example, it is expected that the volume of demand for microfiltration membranes to clean up waste waters and other environmental protective measures in the next ten years will rise annually by 14%; and the tempo of growth in demand for membranes in the chemical industry is estimated to be 7.5%, which correlates with general predicted indices for growth in this sector of the economy [10, 11]. The tendency which has been built up in world practice requires serious interpretation of the state and routes for development of membrane materials and searches for optimum regions of their application in the contemporary national economy.

In the present communication, we shall concern ourselves with the results of studies carried out in the "Khimvolokno" NPO on developing hollow fibres and modules based on them for membrane separation, in those directions which correspond to the maximum extent to the world level which largely determine prospects for industrial realization in the near future. In our view, gas separating and ultrafiltering units based on hollow fibres are such directions.

Gas-separation-membrane technology is developing rapidly. According to the predictions of the weekly publication, "Diamond," the world volume of sales in gas-separating membranes in 1990 will rise 50-fold as compared with those in 1982. According to the estimates of the Dow company (USA), the market for gas-separating membrane modules will increase from 3 million dollars in 1982 to 145 million dollars in 1990 [12]. According to other data, the volume of realization of units for gas separation was 60 million dollars in 1984; in 1990 it will rise to 500 million dollars [8, 9]. Of the new regions of application of membrane gas separation we may note dehumidification of air, extraction of air from off-gases, increasing the efficiency in ozone preparation, and the development of a controlled gas medium for storage of agricultural products [12].
Based on gas-separating hollow-fibre membranes, the following are being produced in an experimental scale or in an industrial one: units for extraction of hydrogen, carbon dioxide, methane, units for air separation [13], units for separating carbon dioxide from biological gas mixtures, for the preparation of hydrogen from the off-gases in ammonia production, and units for purifying air from acetone or perchloroethylene [14]. For example, the application of a unit based on hollow fibres made from an aromatic polyamide ("Dupont" company, USA) for extracting hydrogen from off-gases in the hydro treatment of gas oil cuts down capital expenses by 25% as compared with the traditional cryogenic or absorption processes for removal of hydrogen in petroleum processing manufacturing units [13]. The advantages of membranes become obvious only in separating mixtures whose components differ sharply in their permeability, for example, H₂ and CH₄. For gases with closely similar permeabilities, for example, N₂ and O₂, the membrane method cannot withstand competition with the cryogenic one in large-sized units or with adsorption technology in the case of units of medium size [8, 9].

In the "Khimvolokno" NPO, the development of membrane technology for separating gases using hollow homogeneous or asymmetric hollow fibres, including scientific studies, experimental work, and introduction of processes is being carried out in the following basic directions:

— enrichment of air with oxygen for development of a breathing mixture in medicine, reducing the toxicity of exhaust gases in internal combustion engines, and the development of closed loops for the purification of waste water (aeration);