CHEMISTRY AND TECHNOLOGY OF CHEMICAL FIBRES

HOLLOW FIBRES FOR BAROMEMBRANE SEPARATION OF LIQUIDS

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Hollow fibres for reverse osmosis are spun from solutions of polymers in mixtures of a solvent with a swelling agent; the solvent must have a higher vapor pressure than the swelling agent and must evaporate in the preforming stage to prevent formation of a layer of highly concentrated solution on the outside of the liquid fibre which decomposes into phases according to a spinodal mechanism on entering the spinning bath. The layers of the solution near the center of the liquid fibre decompose into phases according to a nucleation mechanism. After hydrothermal treatment (annealing), a hollow fibre with a wall of asymmetric structure is formed, and the surface layer only has diffusion permeability while the layer nearer the center of the fibre has phase permeability. In order to increase the permeability of the ultrafiltration fibre and fibre matrix for reverse osmosis, the precipitating agent must primarily diffuse inside the jet of spinning solution during spinning.

Membrane separation processes have opened up serious prospects for solving many economic, technical, and ecological problems and problems related to human health over the past quarter of a century. The concept "semipermeable membrane" means some material body, a film, the wall of a tube or hollow fibre, which is permeable to certain components of liquid or gaseous mixtures and impermeable to other ingredients of this system. The membrane separation process is usually characterized by three flows: fed to the membrane, passing through the membrane, and going away from the membrane. The driving force of membrane separation is in all cases the difference in chemical potentials on both sides of the membrane, manifested as pressure and temperature drops, difference in electric potentials, difference in concentrations, etc.

Membrane separation processes are now conducted with membrane installations that ensure rational conditions for creating the difference in chemical potentials, transport of the systems to be separated to the membrane, and removal of target products and wastes. The specific separating area of the membranes, which predetermines removal of the target product from the unit of working volume of the separation apparatus with all other conditions being equal, plays a large role in the rational organization of the separation process.

Increasing the specific separating area per unit of working volume of the apparatus has been successfully solved in international practice by using hollow fibres with semipermeable walls as the membranes. Moreover, separation installations using hollow fibres do not require special drainage systems.

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A list of symbols used in the article is given below (in some cases, the symbols are defined directly where they occur):

- $J_0$ — volume (flow) of liquid fed to the membrane per unit of time;
- $J_1$ — volume (flow) of liquid passing through the membrane per unit of time;
- $J_2$ — amount of dissolved substance passing through the membrane per unit of time;
- $D_1$ — diffusion coefficient of water in the membrane;
- $D_2$ — diffusion coefficient of dissolved substance in the membrane;
- $V$ — molar volume;
- $C_1$ — average concentration of water in the membrane;
- $\Delta C_2$ — difference in the concentrations of dissolved...
Fig. 1. Solubility diagram of cellulose acetate (I) and polysulfone (II): 1) carbon tetrachloride; 2) ethylene carbonate; 3) methylene chloride; 4) acetone; 5) dimethyl sulfoxide; 6) dimethylacetamide; 8) acetic acid; 9) formamide; 10) ethanol; 11) glycerin; 12) water; 13) mixture of acetone and formamide (6:4).

*As in Russian original, 7) is omitted—Publisher.

Fig. 2. Kinetics of evaporation of solvent in the stage of preforming of membranes for reverse osmosis. Typical picture, explanations in text.

BAROMEMBRANE PROCESSES

Membrane separation processes in which the pressure difference on both sides of the membrane is the basic driving force are frequently called baromembrane processes. They include reverse osmosis, nanofiltration, ultrafiltration, and microfiltration. The mechanism of some of the processes is still debated, but most investigators agree that sufficiently reliable opinions have already been formed about them and they are being used successfully in practice.