Lecture №15. Diffusion phenomena in the adsorption and extraction processes in systems with a polymer solid phase

Aim: Describe the process of adsorption. Analyze the features of the adsorption process with the participation of polymeric materials. Discuss the features of the mechanism for moving the dispersed substance in a non-porous material during extraction.

Lecture summary: ***Adsorption.*** Unlike drying, which is characterized by a large amount of materials that vary in the number of dried ma and structure, and a small number of substances distributed, a limited amount of solid phase materials takes part in adsorption. on the contrary,range of absorbed substances - gases and vapors. The most widely used physical adsorpions in absorbers are activated carbons, forces and cages, zeolites, and activated alumina. However, polymeric materials often act as adsorbents (ion exchange processes in ionites are especially indicative in this regard).

As is known, the condition of complete equilibrium between phases is characterized by equality of the chemical potentials of the components in the distribution phases. Since the calculation of chemical potentials for the solid phase presents considerable difficulties, the diffusion equilibrium in most cases is determined experimentally. The amount of the substance to be distributed held by the solid phase depends to a great extent on the structure of the adsorbent. As noted earlier, in the non-porous polymeric material, the sorption isotherm - desorption of water vapor almost follow the linear law, as, for example, in experiments on the extraction of low molecular weight compounds with water from polyamide-6.

It is shown that, in the general case, the sorption and desorption branches of the equilibrium curves for polymers that are little swelling in water and are in a highly elastic state at experimental temperatures often coincide. This condition is conditional on the reversibility of structural changes in this state; I accompany the processes of sorption - desorption of polymers. It is shown that, in the general case, the sorption and desorption branches of the equilibrium curves for polymers that are little swelling in water and are in a highly elastic state at experimental temperatures often coincide. This is due to the reversibility of structural changes in this state, accompanying the processes of sorption-desorption of polymers.

If the non-porous polymer material is in the glassy state and the temperature of the experiment is below the glass transition temperature, then a hysteresis is observed between the sorption and desorption curves, covering the entire moisture content. In this case, the appearance of sorption hysteresis can be explained by the increased rigidity of the macromolecular chains of the polymer in the glassy state, which impedes the flow of relaxation processes. Due to the high rigidity of the macromolecular chain, structural changes caused by adsorbed water molecules, which are energetically most advantageous at maximum moisture and develop a certain pressure force during water desorption, are not accompanied by spontaneous transition of the macromolecules to the initial state.

In general, it should be noted that the adsorption properties of polymeric materials to a large extent depend on the condition of sample preparation and operation - conditions of activation or regeneration, frequency of use (aging of the adsorbent), impurities in the medium, ensuring the isothermal conditions of the process, etc.

Extraction. As studies have shown, the mechanism for moving the substance to be distributed in *non-porous* material during drying and extraction is the same: the concentration-temperature dependences of the coefficients of mass conductivity k for them are of the same type, and the values of these coefficients have the same order.

A comparison of the mass conductivity of the process of drying polyamide-6 and the extraction of low-molecular compounds from this material with water showed their proximity, which may be evidence of a single mechanism of mass transfer - by the type of molecular diffusion.

Due to the complexity of the structure of *capillary-porous* materials, it is generally impossible to empathically accurately take into account the influence of the qualitative and quantitative characteristics of the structure of polymers on the mass conductivity coefficient k. However, approximately the dependence of k on the basic parameters of the porous structure (total porosity ε, determining the pore size, pore size distribution function) can be established.

With an increase in the total porosity of the material, due to the development of the transport system of the pores, the coefficient of mass conductivity increases during drying and extraction in the region of low and medium moisture content.

In the region of large moisture content, the influence on the mass conductivity of the pore size distribution function increases, which plays a large role in the capillary mass transfer mechanism.

The study of the effect of pore size on the coefficient of mass conductivity shows that the magnitude of the latter for macroporous materials is 2–4 orders of magnitude larger than for microporous materials. Such a phenomenon can be explained by differences in the physical mechanisms of moisture transfer in the types of porous materials under consideration (in macroporous – a capillary mechanism is possible; in microporous – a predominant influence of the surface diffusion mechanism is possible). It turns out that from the kinetic point of view, the internal mass transfer during the drying of non-porous materials has more in common with the mass transfer during extraction than during the drying of capillary-porous materials.

In the general case, it should be noted that during extraction from the solid phase, the main mechanism of internal mass transfer is molecular diffusion in a liquid medium, and the temperature dependence of the mass transfer coefficient will be close to the dependence described by the Arrhenius equation.

Thus, the material presented in the manual shows that the main component of mass transfer phenomena are diffusion processes. Knowledge of the diffusion mechanisms of the dispersed substance in the solid phase, the mass transfer rate, optimal process conditions and the achievement of equilibrium concentrations of the dispersed substance are necessary for calculating the technological parameters of the processes and designing the devices and installations.

Questions to control:

1. Description the process of adsorption.
2. Analysis the features of the adsorption process with the participation of polymeric materials.

3. Discussion the features of the mechanism for moving the dispersed substance in a non-porous material during extraction.

Literature:

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