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Simplification or technological development of processes for obtaining polymer materials.

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ABSTRACT

This article is devoted to the technology of polymer production and its continuous improvement in accordance with the state of the art. However, there are basic technological schemes for the production of polymers, and one should know the basic laws of the technological process for the production of various polymers. The main methods for producing polymers are polymerization, polycondensation, and chemical transformations of polymers.

Keywords: polymerization, polycondensation, chemical transformations of polymers, homopolymerization, copolymerization.

Polymerization is the process of obtaining high molecular weight compounds by repeatedly attaching molecules of a low molecular weight substance (monomer) to the active center of the growing chain.

Depending on the number of monomers in the reaction medium, homopolymerization, when one monomer is polymerized, and copolymerization, when two or more monomers are involved in the polymerization process, can be distinguished.

Depending on the nature of the active center and the mechanism of chain growth, polymerization is subdivided into radical and ionic.

Depending on the phase state of the monomer, a distinction is made between gas-phase, liquid-phase and solid-phase polymerization.

Methods for carrying out polymerization.

Depending on the physical conditions of the processes, polymerization is carried out in bulk, in solution, in suspension, in emulsion, as well as in solid and gaseous phases. All monomers can be polymerized in different ways, but under industrial conditions, one or two methods are most effective for a particular monomer.

Polymerization in mass. In this method for synthesizing polymers, the monomer is a liquid in which an initiator and a chain transfer agent (to control the molecular weight of the polymer) or a stabilizer are dissolved. The resulting reaction mass is stirred for the implementation of mass and heat transfer. Initiation can be carried out by adding an initiator, as well as ultraviolet radiation - and radiation exposure. The reaction system can be homogeneous when the polymer is soluble in the monomer, and at the end of the process a concentrated polymer solution or its melt is obtained. If the resulting polymer is insoluble in the monomer, then the reaction system is heterogeneous when the polymer forms a separate liquid or solid phase.

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The advantages of polymerization in the mass are:

- high purity of the obtained polymer (absence of contaminants introduced by the solvent during other polymerization methods);

- no stage of processing (isolation) of the polymer in order to remove the solvent;

- no stage of polymer drying;

- the polymer is obtained in the form of a finished product and does not require mechanical processing (sheet organic glass, billiard balls, chess pieces).

The lack of polymerization in the mass are:

– an increase in the viscosity of the system, which makes mixing difficult and leads to the formation of a polymer with a high molecular weight (due to an increase in polymer concentration during polymerization);

– due to the high exothermic of the process and gel effect, heat dissipation is greatly complicated.

The noted disadvantages impede the wide practical application of the considered method, however, this synthesis method is used in the polymerization of ethylene, styrene and methyl methacrylate. In these cases, the efficiency of heat removal is ensured by interrupting the process at early stages or by carrying out polymerization in several stages.

Polymerization in solution. This is a method of carrying out polymerization in which the starting monomer is in a liquid phase in a dissolved state. The reaction system can be homogeneous or heterogeneous depending on the solubility of the catalyst and the resulting polymer in the reaction medium. The solvent must be inert to the monomer and polymerization agent; most often these are aliphatic or aromatic hydrocarbons. The temperature can be varied within the range in which the monomer and solvent remain liquid. For example, cationic solution polymerization of isobutylene is carried out at minus 100 ° C. High temperature processes are often carried out under overpressure to keep the reaction mixture from boiling. The concentration of the monomer in the solution is varied within wide limits.

In industry, all processes of ionic and most of the processes of coordination-ionic polymerization are carried out by the method of polymerization in solution, for example, the synthesis of stereoregular rubbers, low-pressure polyethylene, polypropylene, copolymers of ethylene with propylene, thermoplastic elastomers, polyisobutylene, polyformaldehyde. Radical polymerization in solution is economically less profitable than in bulk or dispersed aqueous media, therefore it is used only in cases where the final product is used in the form of a solution (varnish, glue) or when the required polymer cannot be obtained by other methods (for example, polyacrylates, polyvinyl acetate , expanded polystyrene, polytetrafluoroethylene).

In industry, solution polymerization is carried out in apparatuses equipped with stirrers, circulation pumps or other mixing devices, less often in tubular or column type apparatuses, continuous processes are usually in cascades of series-connected flow-through mixing reactors. The thermal regime of the process is controlled by heat exchange through the jacket of the apparatus, as well as by preliminary cooling of the solvent and monomer.

With large reaction volumes, additional cooling devices (coils, tubulars, hollow plates) are built into the apparatus. Efficient heat removal and precise maintenance of the specified process temperature can be achieved by evaporating part of the solvent from the reaction zone during its boiling. After condensation in a remote cooler, the solvent is returned to the reactor.

After completion of the reaction, the solvents are removed by evaporation under vacuum or by steam distillation. Catalyst traces are neutralized. The polymer is dried under vacuum or in a fluidized bed.

Advantages of polymerization in solution: it is possible to fine-tune the concentration of reagents, temperature, structure and composition of homo- and copolymers, to obtain high-viscosity polymers; inert solvent provides easy control of heat dissipation and viscosity of the reaction mixture.

Disadvantages: the need to isolate and dry the resulting polymer, significant capital investments and energy costs due to the circulation and regeneration of large amounts of solvent; the solvent can participate in chain transfer and makes it difficult to obtain high molecular weight products; the polymer can be contaminated with solvent residues and impurities contained in it.

Polymerization in suspension. This method is used industrially for the polymerization of water-insoluble monomers. Monomers are dispersed in water in the form of small droplets, which are stabilized with protective colloids, surfactant additives and stirring. The size of the resulting monomer droplets depends on the stirring speed, the ratio of the monomer taken to the water, on the type and concentration of the stabilizer.

Initiators used are soluble in the monomer. Each drop is considered as a microreactor in which polymerization takes place. The kinetics of polymerization inside the droplets of the monomer does not differ from the polymerization kinetics in the mass.

The advantages of suspension polymerization are:

– dispersion medium - water - provides effective heat removal;

– the polymer has a narrow molecular weight distribution, since in small droplets it is not difficult to control the chain length;

– the polymer is obtained in the form of granules and spherical particles;

– the resulting polymer is easily separated from water by filtration, washing with water removes residues of surfactants;

– the resulting polymer in the form of granules and chips is easily processed by injection molding or dissolution to obtain adhesives.

The disadvantage of slurry polymerization is the need to remove residual stabilizers, which heavily contaminate wastewater.

Polymerization in suspension is a competing technological process that develops in parallel with polymerization in mass. The process is used to obtain special grades of product, mainly expanded polystyrene. Suspension production method - a semi-continuous process - is characterized by the presence of additional technological stages (creation of a reaction system, isolation of the obtained polymer) and periodic use of equipment at the stage of polymerization. The process is carried out in reactors with a volume of 10–50 m^3, equipped with a stirrer and a jacket. Styrene is suspended in demineralized water using emulsion stabilizers; the polymerization initiator (organic peroxides) is dissolved in the monomer drops, where the polymerization takes place. As a result, large granules are formed in a suspension of the polymer in water. Polymerization is carried out with a gradual increase in temperature from 40 to 130 ° C under pressure for 8-14 hours. From the resulting suspension, the polymer is isolated by centrifugation, after which it is washed and dried. The regularities of suspension polymerization are close to the regularities of polymerization in the monomer mass, but the heat removal and mixing of the system components are significantly facilitated.

Conclusion.

The performed analysis of technological processes for the synthesis of polymers, as well as the experimental and theoretical studies carried out made it possible to substantiate the expediency of the synthesis of water-soluble polymers of the acrylic series in concentrated aqueous solutions of monomers in two stages, with the combination of polymerization and drying processes at the second stage.

A method is proposed for calculating the processes of heat and mass transfer during the synthesis and use of polymer systems, taking into account the change in the thermophysical properties of the system. The application of the tau method to the solution of problems described by a system of second-order differential equations of parabolic type and ordinary differential equations is developed.

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