Development of catalytic processing of polycarbonates

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Relevance of the research topic. Biphenol A polycarbonate (PC) due to its high physical and mechanical properties (excellent transparency, thermal stability, high mechanical strength and thermal distortion temperature) and chemical properties (resistance to alkalis and acids and to most organic solvents) is widely used in many fields of industry - building materials, sports equipment, unbreakable materials for glazing, exterior and interior of cars. The main environmental problems are the accumulation of plastic and environmental pollution from highly toxic industrial waste. Global PC consumption in 2023 amounted to about 7.85 million tons, according to analysts' forecasts, the average annual growth rate of this volume in the period from 2023 to 2028 will be 4%. Currently, most of the plastic products that have expired are disposed of by being disposed of in landfills or incinerated in incinerators along with other solid waste, these disposal methods cause enormous environmental damage. It is generally accepted that mechanical recycling is the most environmentally friendly and cost-effective way to dispose of used polycarbonate. However, the limiting factor in the continuous mechanical recycling of PCs is the deterioration of the optical qualities of the resulting material and, in this regard, its physico-mechanical properties. The instability of plastic to ultraviolet radiation (UV) is another limiting factor in mechanical processing. Under the influence of UV, the O-C oxygen bonds of the PC macromolecule break, which leads to a change in its structure (this effect also leads to a decrease in mechanical strength and a deterioration in the optical properties of plastic), and therefore such polycarbonate is unlikely to be suitable for mechanical processing. Taking into account the above, it can be concluded that there is an urgent need to develop and implement polycarbonate waste management technologies that would allow not just to obtain

energy (as in combustion) or a new plastic material with possible deterioration of physical and mechanical properties (during mechanical processing), but to produce either the initial monomers of plastics (in the case of PCs, these are bisphenol A), or other high-margin healthy foods. This makes it possible to make a chemical method of plastic recycling.

Thus, the relevance of this work is in the study of chemical processing of polycarbonate based on bisphenol A to obtain useful products.

The goal of this work is to develop an effective method for the catalytic processing of recycled plastics based on bisphenol A polycarbonate to produce compounds that can then be used as raw materials for the production of new products.

The tasks of the work.

To achieve this goal, the following tasks were solved:

1. To develop methods of reaction mass analysis;

2. To investigate the patterns of formation of bisphenol A (BPA), ethylene carbonate (EC) and their esters;

3. Search for and establish the mechanism of acidic and basic catalytic systems for the intensification of glycolysis processes of various secondary polycarbonates.

4. To develop a mathematical model of the glycolysis process;

5. To choose optimal process conditions;

6. To evaluate the possibility of using the products obtained during the destruction of PC as starting materials for the synthesis of new compounds.

The scientific novelty of the work:

1. For the first time, the processes of acid- and base-catalytic glycolysis of polycarbonate based on BPA have been systematized and similar mechanisms of action of catalysts of various nature have been established.

2. A mathematical description of the processes of acid- and base-catalytic glycolysis of polycarbonate is proposed.

3. A method has been developed for the chemical processing of polycarbonate plastic waste based on BPA, which makes it possible to obtain substances that can later serve as raw materials for the production of epoxy-diane resins.

Theoretical and practical significance of the work:

1. A method has been developed for the chemical processing of plastic waste based on bisphenol A polycarbonate, which makes it possible to regulate the composition of reaction products using various types of catalysts, provided they are dissolved in the reaction medium, within the framework of a single technology.

2. It has been established that the products of acid glycolysis of PC are unstable under the given conditions of the process and undergo further decomposition. The described property is not observed with glycolysis products and the main agents.

3. A universal mathematical model of the PC glycolysis process has been developed, which makes it possible to describe the dependence of PC consumption and the formation of reaction products when using Lewis acids and basic agents as catalysts.

4. Chemical processing of PC is accompanied by a physical process (diffusion of solvent and catalyst into the PC structure and polymer swelling) and a chemical process (destruction of the polymer chain with the formation of lower molecular weight oligomers);

5. The influence of the cation of the main catalyst and the activity of the alkali metal, which is part of the catalyst, on the rate of PC depolymerization has been established.

6. A method has been developed for the chemical processing of PC into useful chemicals, which can later be used as raw materials for the production of PC and epoxy resins.

The main provisions for the defense:

1. Mechanisms and kinetic parameters of secondary PC glycolysis under acidic (zinc and iron chlorides) and basic catalysis (alkali metal hydroxides and carbonates) conditions at different temperatures.

2. Differences in kinetic patterns and reaction products during glycolysis in the presence of various types of catalysts.

3. Highly selective method for the production of BPA by acid glycolysis of PC.

4. A method for obtaining functional derivatives of BPA during basic catalysis.

5. The use of hydrolysis products, in particular BPA, for the production of epoxy-diane resins.