CATALYTIC SYSTEMS FOR SYNTHESIS PROCESSES OF PLATFORM CHEMICALS FROM RENEWABLE RAW MATERIALS

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Relevance of the research. In recent decades, the scientific community has developed a clear understanding of the future development of the chemical and fuel industries, in which chemicals synthesized from biomass play an important role. The development of technologies for the production of chemicals from biomass is assessed by modern researchers as a global task, the solution of which requires the fulfillment of fundamental requirements of chemical, technological, economic, social and environmental nature. Thus, the search for and development of new catalysts for the processes of conversion of plant biomass components, such as cellulose, inulin, hemicellulose, etc., into platform chemicals seems to be an urgent scientific task, the solution of which will allow the creation of effective technologies for the synthesis of a wide range of platform compounds and their integration into existing chemical production at the lowest cost.

The aim of the work is to develop new catalytic systems, including those with magnetic properties, for the processes of conversion of plant polysaccharides (cellulose, inulin) into platform chemicals (sugar alcohols, glycols, gluconic and glucaric acids).

Research objectives:

1) Provide theoretical justification and forecasting of the properties of heterogeneous catalytic systems for the processes of hydrolytic hydrogenation, cellulose hydrogenolysis, hydrolytic hydrogenation of inulin and hydrolytic oxidation of cellobiose. Identify the structural features of existing catalytic systems, the presence of which increases the yields of the main reaction products and the stability of the catalysts.

2) Characterize the physicochemical features and technological parameters of the processes of catalytic conversion of plant polysaccharides, which contribute to an increase in the yield of sugar alcohols, glycols, gluconic and glucaric acids.

3) Develop methods for the synthesis of heterogeneous catalytic systems intended for hydrothermal conditions of the processes of hydrolytic hydrogenation, cellulose hydrogenolysis, hydrolytic hydrogenation of inulin and hydrolytic oxidation of cellobiose based on noble metals and carriers of various types, including those with magnetic properties.

4) Conduct physicochemical studies of the developed catalytic systems and test them in the processes of conversion of plant polysaccharides in order to determine composites with maximum activity and stability under hydrothermal process conditions.

5) Study the effect of process parameters on the main characteristics (conversion of feedstock, yield and selectivity for target products) of the processes of hydrolytic hydrogenation, cellulose hydrogenolysis, hydrolytic hydrogenation of inulin and hydrolytic oxidation of cellobiose, carried out in the presence of the corresponding most active catalytic systems.

6) Determine the optimal values of the process parameters of the processes of hydrolytic hydrogenation, cellulose hydrogenolysis, hydrolytic hydrogenation of inulin and hydrolytic oxidation of cellobiose, ensuring the maximum yield of the target products: sorbitol, mannitol, ethylene glycol, propylene glycol, gluconic and glucaric acids.

7) To study the kinetics of the processes of hydrolytic hydrogenation, cellulose hydrogenolysis, hydrolytic hydrogenation of inulin and hydrolytic oxidation of cellobiose carried out in the presence of the corresponding most active catalytic systems.

8) Based on the obtained experimental data of kinetic studies, to create mathematical models of the reactions under study, select adequate kinetic models and calculate their parameters.

9) To develop laboratory process regulations for the synthesis of catalysts and processes of catalytic conversion of plant polysaccharides.

Scientific novelty of the work:

A fundamental study was conducted to solve an important national economic problem: formation of a scientific and technical reserve for the creation of a technology for the synthesis of chemicals in demand by industry (sorbitol, mannitol, ethylene glycol, propylene glycol, gluconic and glucaric acids) from renewable raw materials (plant polysaccharides). The study yielded new data on the methods for the synthesis and modification of heterogeneous catalytic systems, including those with magnetic properties, intended for hydrothermal processes of hydrolytic hydrogenation, cellulose hydrogenolysis, hydrolytic hydrogenation of inulin and hydrolytic oxidation of cellobiose. For the first time, the physicochemical foundations and kinetic aspects of the process of hydrolytic hydrogenation of microcrystalline cellulose in the presence of Ru-containing catalysts based on hyper-crosslinked polystyrene in a subcritical water environment were studied. Methods for the synthesis of optimal catalysts were developed, and their physicochemical studies were carried out. New data on the effect of process on cellulose conversion and selectivity for the main products have been obtained. A formal description of the process kinetics has been given.

For the first time, Ru-containing catalysts on mesoporous silicon dioxide and hypercrosslinked polystyrene with magnetic properties have been proposed for the processes of cellulose hydrogenolysis to glycols and hydrolytic hydrogenation of inulin to mannitol. Methods for the synthesis of such catalysts have been developed, and the physicochemical principles of the technology for converting cellulose to ethylene glycol and propylene glycol using magnetic catalysts have been developed. New data on the effect of conversion process parameters on the yield of the main products have been obtained. A formal description of the process kinetics has been given.

Also for the first time, Pt-containing heterogeneous catalytic systems based on hyper-crosslinked polystyrene were used for the process of hydrolytic oxidation of cellobiose to gluconic and glucaric acids. New data on the effect of process conditions on cellobiose conversion and selectivity for the main products were obtained. Based on the results of kinetic studies, a reaction scheme for the hydrolytic oxidation of cellobiose was proposed, and a formal description of the process kinetics was given.

The scientific novelty of the results obtained during the dissertation research is also confirmed by Russian patents for invention: "Method for catalytic conversion of cellulose to hexitols" No. 2497800. "Method for synthesis of polymer magnetically separable sorbent" No. 2737259. "Method for producing furfuryl alcohol using a magnetically separable catalyst" No. 2775227.

The practical significance of the work.

The materials obtained during the study have an obvious practical focus and can be used to create effective, environmentally friendly industrial technologies for the catalytic conversion of plant biomass into popular chemical compounds. The practical significance of these materials lies in the formation of a scientific and technical reserve for the technology of obtaining sorbitol, mannitol, glycols, gluconic and glucaric acids through the catalytic transformation of cellulose, inulin and cellobiose. Based on the results of the dissertation research, the national economic task of creating a scientific and technical reserve for this technology was solved..

Thesis to be defended:

Main provisions submitted for defense. The following provisions are submitted for defense of the dissertation:

- methods for synthesizing Ru- and Pt-containing heterogeneous catalysts based on a porous matrix of hyper-crosslinked polystyrene for the processes of, respectively, hydrolytic hydrogenation of microcrystalline cellulose to sorbitol and hydrolytic oxidation of cellobiose to gluconic and glucaric acids;
- methods for synthesizing Ru-containing heterogeneous catalysts with magnetic properties based on mesoporous silicon dioxide and hyper-crosslinked polystyrene for the processes of

hydrogenolysis of microcrystalline cellulose to ethylene glycol and propylene glycol and hydrolytic hydrogenation of inulin to mannitol;

- conditions for carrying out the catalytic conversion of cellulose, inulin and cellobiose, ensuring the maximum yield of target products (sorbitol, mannitol, glycols, gluconic and glucaric acids);

- schemes and mathematical models of the processes of conversion of cellulose, inulin and cellobiose into the specified platform chemicals using synthesized catalysts; - physicochemical principles of the technology of catalytic conversion of plant polysaccharides into platform chemicals.