Development of chemical metallization processes of highly porous ceramic materials for catalysts

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Relevance of work

Burning fuel creates the majority of gaseous and aerosol atmospheric pollution, including carbon monoxide. The toxic properties of CO are explained by the absorption of hemoglobin in the blood, transfer from the lungs to various tissues, which leads to oxygen starvation and death of the body.

Currently, about 300 million tons of carbon monoxide are released into the atmosphere as a result of human activities. Moreover, 70-75 percent of emissions are generated by burning fuel in internal combustion engines, about 10 percent by burning coal and firewood, about the same amount by burning household waste, and about 5 percent by forest fires. Some part of carbon monoxide is created by technological processes in industry (for example, metallurgical, oil refining, chemical).

At the same time, in the modern nuclear industry, one of the urgent tasks is the purification of gas emissions of nuclear power plants from volatile radionuclides - nuclear fission products such as Cs, I, Ru, Tc, H, Se, Sb, Te, Xe, Kr, etc. A prerequisite for the disposal of radioactive waste (RW) is their conversion to safe storage forms with the maximum reduction in waste volume.

One of the promising methods for solving these problems is the creation of sorbents and catalysts based on ceramic highly porous cellular materials (HPCM) with a deposited layer of catalytically or sorption-active metals, for example, Ni, Co, Cr, Pd, Ca, V, Cu, Ag, Zr and their compounds. The characteristic arched labyrinth structure of the HPCM, combining transport macropores with a size of 0.5-4.5 mm with micropores of nodes and partitions with sizes of 0.1-10 microns, allows efficient mass transfer processes with a high degree of mixing and dispersion of the gaseous medium and the creation of low-volume catalysts sorbents with high specific characteristics at low concentrations of reacting substances. A durable ceramic frame eliminates the inherent disadvantages of powder, tablet and extruded catalysts: abrasion and abrasion.

Small-volume ceramic sorbents providing compact temporary storage of radioactive waste can be buried by cementing or transferring them to durable chemically resistant ceramics with the addition of special binders or vitrification in special glass melting furnaces.

High-porous cellular sorbents and catalysts with a supported metal active layer (Co, Pd, V, Cu, Ag) have been developed at D.Mendeleev University of Chemical Technology of Russia and have been successfully tested in the processes of afterburning of carbon monoxide and hydrocarbons, reduction of nitrogen oxides, chemisorption of gaseous compounds of radioactive cesium, radioactive iodine, vapors selenium, tellurium and antimony.

The metal active layer on the indicated sorbents and catalysts was formed by a rather complicated multistage physical method - by impregnating the mesh-cellular frame in one or several operations in melts or solutions of the corresponding salts, followed by heat treatment and reduction with hydrogen gas in a hydrogen reactor at high temperatures. A simpler and more promising way of forming a metal layer on the surface of highly porous ceramic materials may be the method of chemical metallization.

Despite the fact that the processes of chemical metallization of dielectrics have been studied and are widely used to give them the necessary technical properties in order to solve various practical problems, information on the chemical metallization of highly porous cellular ceramic materials (HPCM) is practically absent in the literature.

The purpose of the thesis

The development of chemical metallization processes of ceramic highly porous cellular materials in order to give them high catalytic activity.

To achieve this goal, the following tasks were solved:

- the establishment of the influence of the modes of obtaining highly porous cellular ceramic material on the process of chemical metallization and on the catalytic activity of metallized HPCM;
- study of the influence of the parameters of the process of pretreating a ceramic surface before chemical metallization on the metallization rate and catalytic activity of metallized HPCM;
- study of the effect of solution compositions and chemical metallization processes of highly porous ceramic samples on the catalytic properties of metallized HPCM.

Scientific novelty and practical significance of the thesis

For the first time, the effect of the electrolyte flow rate on the uniform distribution of the metal inside the HPCM is shown.

It has been established that the temperature regime of sintering of corundum ceramics affects the rate of subsequent metallization and the catalytic activity of metallized HPCM. The optimum sintering temperature was determined, which was 1450 ° C.

A technological process for preliminary preparation of the surface of corundum ceramics before metallization is proposed, including treatment with white spirit, etching in a mixture of hydrofluoric and sulfuric acids and processing in a palladium activator, which allows obtaining solid, fine crystalline coatings with good adhesion with high catalytic activity.

Processes have been developed for the production of HPCM metallized with silver, copper, nickel and cobalt with high catalytic activity.

It has been shown that chemically cobalted ceramic samples precoated with cerium oxide are resistant to oxidation during the conversion of CO to CO_2.