Polyoxide Ni-Cu-Cr catalysts for neutralization of emissions of industrial enterprises

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Introduction

At present the problem of ecological protection of the environment from emissions of industrial enterprises, i.e. chemical safety becoming increasingly important. Toluene, xylene, styrene, butyl acetate, isobutanol, formaldehyde, acetone, ethanol, etc., which have a strong toxic effect on living organisms, are among the main harmful emissions from industrial facilities (furniture shop, paint production, cable plant, the production of pharmaceuticals, printing venture, etc.). Toluene, xylene and ethyl benzene are major part of the solvents that are used in various industries and presented in the gas emissions. At present it is known that the catalytic method is the most effective way to neutralize. In this regard, the development of efficient catalysts in deep oxidation of organic harmful substances is an urgent problem of ecology. Toluene as the main component of emission of furniture, cable, footwear and other industries we have chosen as a model substance.

Materials and Methods

The catalysts were prepared by capillary impregnation of mixed aqueous solutions of nitrate salts of metals on aluminum oxide on its moisture content, followed by drying at 453-473K (4-5 h) and calcination at 873K (1.5 h) in air [1]. Granular 0-Al2O3 (5 = 100m2/g), modified by 2% Ce was used as a carrier. As a result of heat treatment the surface perovskite CeAlO3, stable up to 1373K, was formed.

The content of the initial reactants and reaction products were determined at the “Crystal 2000M” chromatograph with a flame ionization detector with a capillary column 50 m long.

The catalytic activity of the catalysts was determined in a flow installation in the deep oxidation of toluene in air at different temperatures (523-773K), space velocity (5-15 × 10^3 h^{-1}) and the concentration of toluene (320 mg/m³) in the initial mixture of air.

Results and Discussion

In studying the effect of process parameters (temperature, space velocity, the concentration of toluene in the gas mixture) to complete conversion of toluene (to CO₂ and H₂O) showed that the synthesized polyoxide Ni-Cu-Cr catalyst supported on a 2% Ce0-Al₂O₃ in the oxidation of toluene at a space velocity 5 × 10^3 h⁻¹, a temperature of 723-773K and the content of toluene in the mixture 100 - 570 mg/m³ provides 98.8% conversion of toluene to CO₂ [2-3].

The synthesized Ni-Cu-Cr / 2% Ce0-Al₂O₃ catalysts have been investigated by X-ray analysis (XRD) and transmission electron microscopy (EM).

Phase composition of catalysts was determined by X-ray diffractometer DRON-4-7, Co-anode, 25kV, 25mA, 20-5-80° C. According to the XRD during the synthesis of catalyst after heating at 873K on the surface of carrier reported the presence of crystals CeO₂ and X-ray amorphous clusters (d = 20-100Å) of variable valence metal oxides NiO, CuO as well as solid solutions of metals CuO (NiO). With the heating of Ni-Cu-Cr / 2% Ce0-Al₂O₃ catalyst occurs not only the crystallization of CeO₂ but also sharply increases the content of α-Al₂O₃, starting with 1273K. A significant decrease in the total surface area of catalysts occurs as heating due to this process.

The morphology, particle size, chemical composition of Ni-Cu-Cr catalysts have been investigated using a transmission electron microscope EM-125K with an increase by 80 000 replicas with extraction using micro-diffraction with an increase in the catalyst component. It was found that in the process of complexity of composition of Ni-Cu-Cr catalysts produced single, double, triple metal oxides, the particle size of which decreases from 50-80 (Ce/Al₂O₃) up to 20-30Å (Ni-Cu-Cr).

The binding energy of oxygen with surface and its reactivity on polyoxide catalysts by methods of temperature-programmed desorption (TPD), oxidation (TPO) and reduction (TPR) has been determined. It was shown that formed Ni and Cu aluminates can be reduced to the initial oxides or mixtures thereof under the influence of H₂ at 973-1223 K. Adsorption of O₂ again on Ni-Cu-Cr catalysts after decomposition of oxides occurs at low temperature (325 K). This points to the high reactivity of the adsorbed O₂, O, and lattice oxygen of dispersed oxides, as well as mixtures thereof, and the ability to easy its re-activation.

References