

to operate stably at high space velocities. The high cost of the platinum group metals is the reason for the development of new approaches to the creation of highly efficient polyoxide catalysts that do not contain noble metals, and which are able to exhibit high thermal stability and resistance to poisoning over a long period of operation (Tungatarova et al., 2014). Creation of catalysts for gas purification, which do not contain noble metals or contain them in small amounts (Zhang et al., 2019), is an important goal. The development of high-performance polyoxide catalysts, which do not contain noble metals and technology for deep oxidation of toxic organic gaseous emissions from industry are relevant. The creation of clean production without harmful exhaust gases and volatile impurities is important today. To achieve these goals, Ni - Cu - Cr catalysts were studied for the purification of volatile organic compounds using toluene by a set of physico-chemical methods to determine the state of active components on the catalyst surface, to increase the activity and stability of samples at high temperatures.

## 2. Experimental

The Ni - Cu - Cr/2 % Ce/ $\theta$  -  $\text{Al}_2\text{O}_3$  catalyst was investigated by the temperature-programmed desorption (TPD) of oxygen and temperature-programmed reduction (TPR) of hydrogen. The adsorption characteristics of the developed catalyst were investigated on the "Chemosorb" analyzer designed for automated TPR and TPD analysis. The oxidized catalyst is heated by a program-controlled process in TPR method. Reducing gas (hydrogen) is passed through it at the same time. The TPD method was used to study pre-activated samples that were saturated with the test reaction gas (oxygen) under isothermal conditions after preparation. The sample was heated at a constant rate and purged with an inert gas (argon) during analysis. The gas that was initially chemisorbed on the surface of the sample began to desorb. The concentration of gas desorbed from the sample was recorded using a thermal conductivity detector.

## 3. Results and Discussion

Figure 1 shows the spectra of thermal desorption of oxygen from oxide Ni - Cu - Cr/ $\theta$  -  $\text{Al}_2\text{O}_3$  catalysts after adsorption of oxygen at 870 K. It can be seen that the amount of oxygen released upon heating to 1,173 K (stabilizing temperature) is increased as the complexity of the composition of the mixed catalyst.

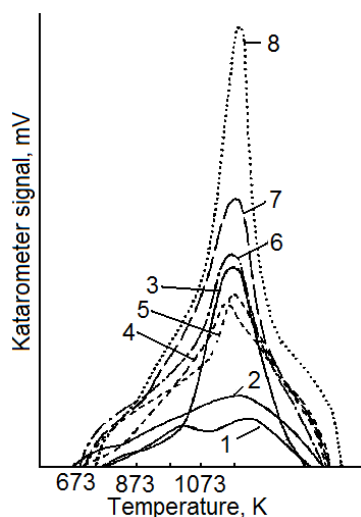


Figure 1:  $\text{O}_2$  - TPD profiles of the catalysts on  $\text{Al}_2\text{O}_3$  after heating in air: 1 - 5 % Ni, 2 - 5 % Cu, 3 - 5 % Cr, 4 - 5 % (Ni + Cr), 5 - 5 % (Cu + Cr), 6 - 8 - 10 % Ni - Cu - Cr at varying the supporting methods of catalysts: 6 -  $\text{NH}_4\text{HCO}_3$ , 7 -  $\text{Al}(\text{NO}_3)_3$ , 8 -  $\text{NH}_4\text{HCO}_3 + \text{Al}(\text{NO}_3)_3$ ,  $T = 873 \text{ K}$ , 1 h

The desorption curve has kinks at 773 K, 923 K and a maximum at 1,023 K, which is due to the desorption of adsorbed oxygen (673 - 873 K) and the decomposition at first (873 - 1,073 K) of copper and nickel oxides (to  $\text{Cu}_2\text{O}$ ,  $\text{Ni}_2\text{O}$ ), and then mixed oxides ( $> 1,070 \text{ K}$ ). The total amount of released oxygen (9.7 mmol per 1 g of active phase) exceeds the possible sorption in each of the oxides. This is obviously due to the dissolution of oxides in the resulting solid solutions in excess of stoichiometric oxygen released at lower temperatures. The total amount of oxygen released from the Ni - Cu - Cr catalyst (mainly due to the weakly adsorbed oxygen)