

depends on the conditions for obtaining of mixed carbonates and their decomposition. It is increased by 2 times when using $\text{NH}_4\text{HCO}_3 + \text{Al}(\text{NO}_3)_3$ in the precipitation mixture.

Calculation of the activation energy of oxygen evolution from the catalyst showed that it is 88 - 89 kJ mol^{-1} for adsorbed oxygen. Desorption energy (E_{des}) for single copper oxides is equal to 128 kJ mol^{-1} , for nickel oxides - 120 kJ mol^{-1} , and for mixed oxides - 140 - 144 kJ mol^{-1} .

The thermal desorption spectra of oxygen from Ni - Cu - Cr catalysts on 2 % Ce/ θ - Al_2O_3 correspond to those described above for the catalyst supported on θ - Al_2O_3 . Calculation of the amounts of released oxygen indicates a significant decrease in specific sorption to 0.64 mmol g^{-1} of the active phase.

Increase in specific adsorption is facilitated by the introduction of Pt (0.93 mol g^{-1}) and Pd (0.75 mmol g^{-1}) into the composition of catalyst. The promoters cause a decrease in the decomposition temperature of mixed oxides by ~ 100 K. The activation energy of desorption differs little from those found for Ni - Cu - Cr supported on θ - Al_2O_3 : E_{des} adsorbed is 90.8 and reaches 96 - 98 kJ mol^{-1} on promoted contacts. E_{des} at the decomposition of mixed oxides is 142 kJ mol^{-1} .

The heating of Ni - Cu - Cr/2 % Ce/ θ - Al_2O_3 at 1,473 K (Figure 2) sharply reduces the release of oxygen in the region of decomposition of metal oxides for the initial and promoted contacts. The adsorbed oxygen region completely disappears in the spectrum of Ni - Cu - Cr and Ni - Cu - Cr + Pt catalysts. The observed phenomena can be explained by the fact that most of the metal oxides interact with the carrier with the formation of large (20 - 100 nm) Ni(Cu) Al_2O_4 aluminates (as shown by the X-ray diffraction method (XRD) and transmission electron microscopy (TEM) methods with microdiffraction). The total surface of the catalysts decreases from 60 to 5 $\text{m}^2 \text{g}^{-1}$, although the content of active elements in the catalyst did not change significantly during heating (emission spectral analysis) (Table 1).

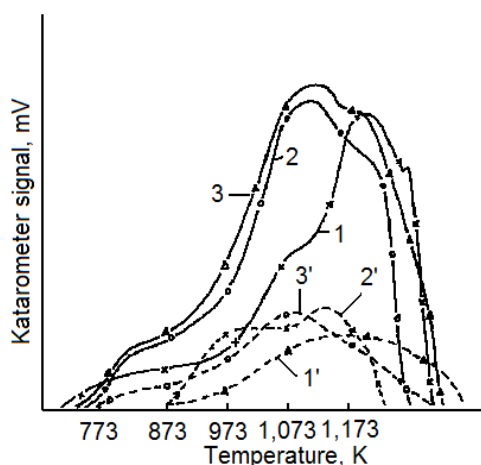


Figure 2: O_2 - TPD profiles of the Ni - Cu - Cr/2 % Ce/ Al_2O_3 catalyst heated in oxygen and promoted with Pd and Pt: 1 - Ni - Cu - Cr/2 % Ce/ Al_2O_3 , 2 - Ni - Cu - Cr/2 % Ce/ Al_2O_3 + Pd, 3 - Ni - Cu - Cr/2 % Ce/ Al_2O_3 + Pt. 1', 2', 3' - catalysts after heating at 1,473 K, T - 873 K

Table 1: Content of elements in the catalysts according to the data of the method of emission-spectral analysis after heating at different temperatures

Catalysts	T, K	Content of elements, %		
		Ni	Cu	Cr
Ni - Cu - Cr/2 % Ce/ θ - Al_2O_3	873	1.8	3.3	0.12
Ni - Cu - Cr/2 % Ce/ θ - Al_2O_3	1,373	1.6	3.1	0.15

The study of the temperature-programmed reduction of Ni - Cu - Cr catalysts on 2 % Ce/ θ - Al_2O_3 made it possible to better understand the mechanisms of oxygen reduction and oxygen removal processes, and also to evaluate the ability of catalysts to adsorb oxygen from the gas phase.

Figure 3a shows that the TPR curve has 4 temperature absorption maxima of H_2 : $T_1 = 523$ K, $T_2 = 573$ K, $T_3 = 673$ K and $T_4 = 1,073$ K, corresponding to the reduction of CuO (T_1), mixed oxides of CuO - NiO (T_2), NiO (T_3) and partially formed Ni or Cu aluminates. The temperature-programmed oxidation (TPO) of the catalyst after its reduction to 1,225 K (Figure 3b) showed that in contact oxygen is readily adsorbed at 357 - 373 K as a wide