Temperature-programmed oxidation (TPO) of catalyst after its reduction up to 1,225 K (figure 3b) showed that oxygen is adsorbed easily, starting from 357 – 373 K, as a broad peak with T^1_m = 523 K, T^2_m = 673 K and T^3_m = 800 – 810 K, which corresponds to adsorption of it on surface (T^1_m) and formation of Ni and Cu oxides. Ni-Cu-Cr/Ce/θ-Al_2O_3 catalyst has undergone profound changes in the phase composition after heat treatment at 1,473 K 5 h (Figure 4a).

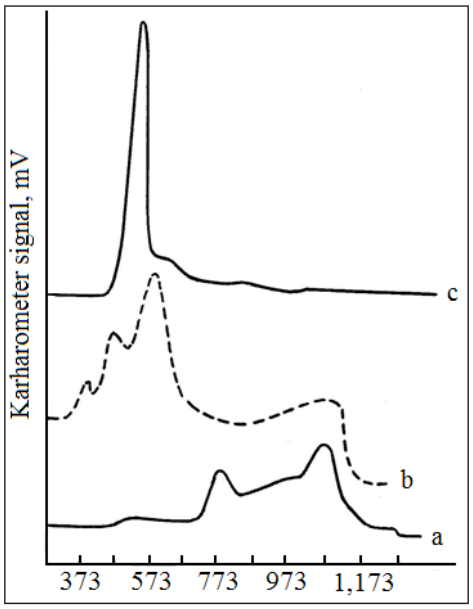

Figure 4 - TPR and TPO spectra of the Ni-Cu-Cr/Ce/θ-Al_2O_3 catalyst:
a - TPR of the initial catalyst, b - TPO of catalyst reduced up to 1,223 K,
c - TPR of catalyst after treatment in oxygen to 973 K, T - 1,473 K, 5 h

Weak bending of curve at 473 K is available in TPR spectrum. The main absorption of H_2 occurs at T_m = 773 and 1,073 K when Cu (Ni) aluminates are reduced. Cu(Ni)Al_2O_4 crystals (2,42 reflex) is also fixed according to XRD. If the reduction temperature of catalyst reaches 1,223 K, the adsorption of oxygen in the initial Ni-Cu-Cr catalyst is carried out at a temperature above than 373 K (figure 4b).

Subsequent temperature-programmed reduction of catalyst indicates on absorption of H_2 only as a single peak (Figure 4c). This indicates that a mixture of Ni(Cu) oxides, which are reduced at 523 K, is synthesized from aluminates.

Thus, Ni-Cu-Cr catalyst is a solid solution of copper and nickel oxides with chromium, included in it, according to the TPD and TPR results. Superstoichiometric surface oxygen with E_{des} = 88 - 89 kJ mol^{-1}, which reacts easily with reducing agents is adsorbed onto its surface. TPD curves and TPO data indicate on its presence in catalyst. Besides mixed oxides the less active Ni and Co aluminates are formed in the oxidation process at high temperatures in catalyst in an oxidizing atmosphere.

Conclusion. As a result of studies, it was found that the highest degree of toluene conversion (to 98.8 %) is observed on three-component Ni-Cu-Cr/2% Ce/θ-Al_2O_3 catalyst with optimal ratio Ni : Cu : Cr = 1.0 : 3.0 : 0.1 at space velocity of 5Ч10^3 h^{-1} and temperature 723 - 773 K. The binding energy of oxygen with surface and its reactivity on polyoxide catalysts were determined by the TPD, TPO and TPR methods. It was shown that formed Ni and Cu aluminates can be reduced to the initial oxides or their mixtures under the influence of H_2 at 973 - 1,223 K. Again, oxygen adsorption on Ni-Cu-Cr catalysts after decomposition of oxides occurs at low temperature (325 K). This point to high reactivity of adsorbed O_2^-, O^-, and lattice oxygen of dispersed oxides, as well as mixtures thereof, and its ability to easy reactivation.

Acknowledgments. The work was supported by the Ministry of Education and Science of the Republic of Kazakhstan (AP05132348).