CHISA 2016 PRAGUE PRES 2016

22nd International Congress of Chemical and Process Engineering
CHISA 2016

19th Conference on Process Integration, Modelling and Optimisation for Energy Saving and Pollution Reduction
PRES 2016

organized by
ČSCHI ČESKÁ SPOLEČNOST CHEMICKÉHO INŽENÝRSTVÍ
CZECH SOCIETY OF CHEMICAL ENGINEERING

Prague, Czech Republic, 27 August - 31 August 2016

P.7.24

Application of oxide copper chromium catalysts for the purification of exhaust gases

[1]T.S. Baizhumanova, [1]Z.T. Zheksenbaeva, [1]S.A. Tungatarova, [1]R.O. Sarsenova, [2]M.A. Sadenova, [3]S.A. Abdulina
[1]D.V. Sokolsky Institute of Fuel, Catalysis and Electrochemistry, 142, Kunaev str., Almaty, 050010, Republic of Kazakhstan; tel. +77272916632, e-mail: tungatarova58@mail.ru;
[2]S. Amanzholov East Kazakhstan State University 34, 30 Gvardeiskoi divisii str., 070000, Ust-Kamenogorsk, Kazakhstan;
[3]D. Serikbayev East Kazakhstan State Technical University, 19, Serikbayev str., 070000, Ust-Kamenogorsk, Kazakhstan

The problem of chemical safety and sanitary air protection is particularly relevant due to the increase of harmful emissions of industrial enterprises, which have a strong toxic effect. The data on studying the process of deep oxidation of toluene on polyoxide nickel-, copper-, chromium-containing catalysts are presented in this paper. Toluene as the main component of emissions the furniture, cable, footwear and other production has been chosen as model substance of neutralization.

Polyoxide catalysts were prepared by capillary impregnation of alumina modified with cerium by mixed aqueous solutions of metal nitrates by incipient wetness of carrier with subsequent drying under 453 – 473 K (4 – 5 h) and calcination at 873 K (1 – 1.5 h) in air.

Toluene content before and after reaction was analyzed on the Crystal – 2000M chromatograph with a flame ionization detector (24.91 Hz) on a capillary column. Catalytic activity of catalysts was determined in flow installation at deep oxidation of toluene in air at various temperatures (523 – 773 K), space velocities (5 - 15×10^3 h^{-1}) and toluene concentration (320 mg/m^3) in the initial mixture.

Figure 1 presents the data obtained in the oxidation of toluene in synthesized nickel-copper-chromium oxide catalysts at 723 K and space velocity 5×10^3 h^{-1}. The Figure 1 shows that the nickel-copper-chromium-containing polyoxide catalysts of the deep oxidation of toluene by activity are located in the following order: Ni-Cu-Cr/2 % Ce/θ-Al_2O_3 (98.8 %) > Ni-Cu-Cr/θ-Al_2O_3 (93 %) > Ni-Cu/2 % Ce/θ-Al_2O_3 (85 %) > Ni-Cr/2 % Ce/θ-Al_2O_3 (76 %) > Ni/2 % Ce/θ-Al_2O_3 (57 %).

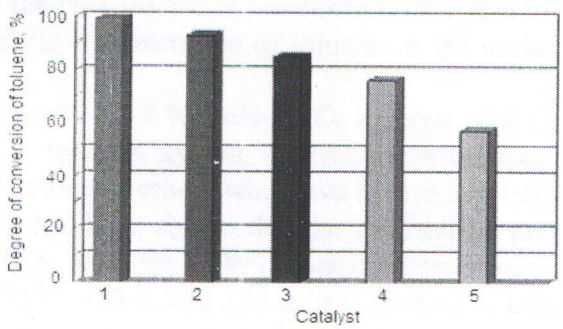

Fig. 1. The oxidation of toluene in air on oxide Ni-Cu-Cr containing catalysts: 1 - NiCuCr/2 % Ce/θ-Al_2O_3; 2 - NiCuCr/θ-Al_2O_3; 3 - NiCu/2 % Ce/θ-Al_2O_3; 4 - NiCr/2 % Ce/θ-Al_2O_3; 5 - Ni/2 % Ce/θ-Al_2O_3

It should be noted that comparison of the activity of multicomponent Ni-Cu-Cr containing catalyst supported on alumina modified by cerium with catalyst supported on

alumina without cerium showed that the conversion of toluene on the catalyst Ni-Cu-Cr/2 % Ce/θ-Al_2O_3 significantly higher (98.8 %) than on the Ni-Cu-Cr/θ-Al_2O_3 (93 %).

Effect of process parameters (temperature, space velocity, concentration of toluene in gaseous mixture) on the completeness conversion of toluene (to CO_2 and H_2O) on the Ni-Cu-Cr/2 % Ce/θ-Al_2O_3 polyoxide catalyst was studied. The degree of oxidation of toluene from the variation of space velocities at different temperatures on the Ni-Cu-Cr/2 % Ce/θ-Al_2O_3 catalyst are presented in Table 1. It can be seen that with the increase of space velocity from 5×10^3 to 15×10^3 h^{-1} degree of oxidation of toluene reduces from 98.5 to 89.3 %, respectively.

Table 1: Effect of temperature and space velocity on the degree of conversion of toluene on the Ni-Cu-Cr/2 % Ce/θ-Al_2O_3 catalyst

T, K	Space velocity, $\times10^3$ h^{-1}		
	5	10	15
	(α), %	(α), %	(α), %
523	73.7	81.0	82.1
573	89.5	85.7	83.8
623	94.7	90.5	85.7
673	97.5	91.5	89.3
723	98.5	93.5	89.3
773	98.5	95.2	89.3
Note: The concentration of toluene in the feed - 320 mg/m^3			

Thus, degree of conversion of toluene to CO_2 reaches the 98.5 – 98.8 % on the Ni-Cu-Cr/2 % Ce/θ-Al_2O_3 catalyst at a temperature of 723 – 773 K and space velocity 5×10^3 h^{-1}.

Influence of concentration of toluene in the initial mixture to the efficiency of its conversion on the polyoxide catalysts of various compositions were studied. The data shows that increasing the concentration of toluene from 100 to 320 mg/m^3 in the initial mixture with air leads to a slight decrease in the degree of conversion of toluene on the two component Ni-Cu/2 % Ce/θ-Al_2O_3 and Cu-Cr/2 % Ce/θ-Al_2O_3 catalysts. A noticeable decrease in activity among two component oxide catalysts were found on the nickel-chromium-containing catalyst from 76.6 to 73.0 %. Ni-Cu-Cr/2 % Cr/θ-Al_2O_3 catalyst was the most stable.

Thus, the optimal conditions of deep oxidation of toluene on oxide Ni-, Cu- and Cr-containing catalysts over 2 % Ce/θ-Al_2O_3 were determined. Degree of conversion of toluene reaches 98.5 – 98.8 % on the Ni-Cu-Cr/2 % Ce/θ-Al_2O_3 catalyst at temperatures of 723 – 773 K, GHSV - 5×10^3 h^{-1} and the concentration of toluene in the initial mixture with air – 100 - 320 mg/m^3.

Polyoxide supported Ni-Cu-Cr/2 % Ce/θ-Al_2O_3 catalyst with desired properties for deep oxidation of hydrocarbons - toluene, xylene, styrene, ethyl acetate, butyl acetate, isobutanol, formaldehyde, acetone, ethanol and others who have severe toxic effects on a living organism and flora was developed. It has been shown that the synthesized polyoxide Ni-Cu-Cr catalyst supported on 2 % Ce/θ-Al_2O_3 provides 98.8% toluene conversion to CO_2 at space velocity of 5×10^3 h^{-1}, temperature of 723 – 773 K and 320 mg/m^3 content of toluene in the feed mixture.

The work was supported by the Ministry of Education and Science of the Republic of Kazakhstan (Grant No 0245/GF4, 0246/GF4).