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PROMOTING EFFECT OF BaO ON THE ACTIVITY OF Ni/Al_2O_3 CATALYST FOR THE HYDROGENATION OF BENZENE AND TOLUENE

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The catalytic activity of Ni/Al_2O_3 for the hydrogenation of benzene and toluene is remarkably enhanced by introduction of a small amount of BaO and the highest activity is obtained with 1.5 wt% BaO. The hydrogenation activity is proportional to the amount of hydrogen chemisorbed on the catalyst and the introduction of BaO into Ni/Al_2O_3 increases Ni metal surface area.

In the case of supported metal catalyst, it is very important to obtain a highly dispersed state of metal, since the resulting increase of metal surface area generally leads to an increase in the catalytic activity. Several authors suggest the effect of Group II A oxide on the dispersion of metal.[1,2] In this paper, we envisage the effect of BaO on Ni/Al_2O_3 for the hydrogenation of benzene and toluene.

Preparation of Catalyst

Al_2O_3 and BaO-doped Al_2O_3: Commercial γ-Al_2O_3(DIA CATALYSTS & CHEMICALS LIMITED) was used as a carrier and the BET surface area was 150 m^2g^{-1}. BaO-doped Al_2O_3 was prepared by impregnation of γ-Al_2O_3 with a solution of barium nitrate corresponding to its pore volume (pore filling), followed by drying at 373 K for 24 h under vacuum and calcination at 1073 K for 24 h in a stream of air.

Ni/Al_2O_3 and Ni/BaO-Al_2O_3: Ni/Al_2O_3 and Ni/BaO-Al_2O_3 were prepared by impregnation of γ-Al_2O_3 or BaO-doped Al_2O_3 with a solution of nickel nitrate (pore filling), followed by drying at 373 K for 24 h under vacuum and calcination at 773 K for 24 h in a stream of air. Ni content was 10 wt%.

Hydrogenation of benzene and toluene

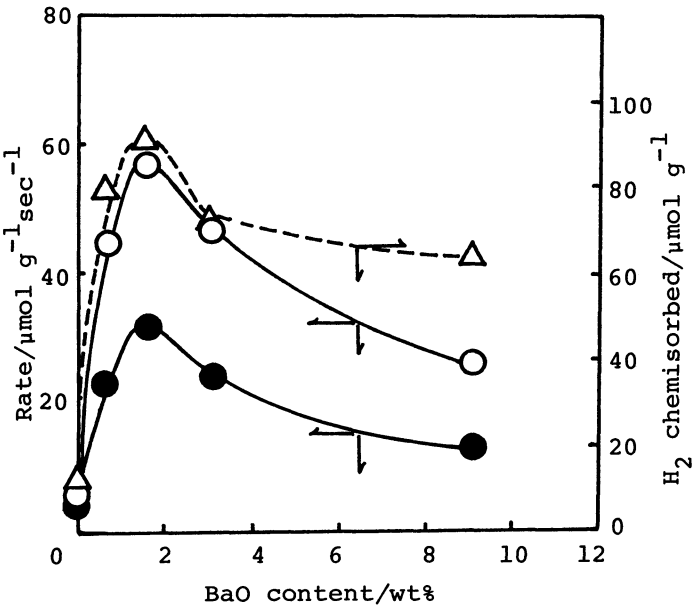

Fig. 1 Rate of hydrogenation of benzene and toluene and the amount of H_2 chemisorbed as a function of the BaO content of $Ni/BaO-Al_2O_3$.
○, benzene; ●, toluene; temp. 413 K;
△, hydrogen chemisorption

The rates were measured in a conventional flow reactor at low conversion (less than 20 %) to avoid heat and mass transfer limitations, under the conditions of temperatures of 373 to 413 K, hydrocarbon partial pressure of 190 Torr, and H_2 partial pressure of 570 Torr. Before the measurement of the rate the catalyst was reduced in a stream of H_2 at 773 K for 3 h in the reactor. Figure 1 shows the promoting effect of BaO on the activity of Ni/Al_2O_3 for the hyrdogenation of benzene and toluene. As indicated in Fig. 1, the activity for both hydrogenation reactions remarkably increases with increasing amount of BaO and the highest activity of Ni/1.5 wt% $BaO-Al_2O_3$ is ca. 10 times larger than that of Ni/Al_2O_3.

Adsorption of Hydrogen

The adsorption measurement was undertaken at room temperature using a conventional gas volumetric system and the amount of adsorption was obtained at the saturated point of the isotherm. As shown in Fig. 1, the amount of hydrogen chemisorbed also increases with an increase in the amount of BaO, indicating that the addition of BaO into Ni/Al_2O_3 remarkably increases Ni metal surface area. Moreover, the good correlation between the activity and the amount of hydrogen chemisorbed indicates that the hydrogenation of benzene and toluene is the structure insensitive reaction.[3,4]

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