INFLUENCE OF WATER ON THE HEAT OF HYDROGEN ADSORPTION ON NICKEL

G. D. Zakumbaeva, Kh. G. Omashev and Ch. Khan

Institute of Organic Catalysis and Electrochemistry
Alma-Ata, USSR

Received September 15, 1976
Accepted December 3, 1976

Water and hydrogen adsorption on Ni-black has been studied by a microcalorimetric method. The heat of hydrogen adsorption is considerably different on clean surfaces and on those covered with 20-50% chemisorbed water. In the former case it varies between 33 and 8 kcal/mol, and in the latter between 26 and 4.6 kcal/mol. The decrease in the heat of hydrogen adsorption is related to the energy requirement of water desorption. On the hydrogen-covered catalyst surface no water adsorption occurs.

The influence of water on hydrogen adsorption on Ni-black has not been elucidated in the literature. At the same time, nickel catalysts are widely used in industrial hydrogenation processes, particularly in the liquid phase at relatively low temperatures. In the present work we have measured the heats of hydrogen adsorption on Ni-black in the gas phase and on a metal surface wetted by various amounts of water. The study was carried out by using a Kalve type microcalorimeter /1, 2/. Ni-black was obtained by reduction of reagent grade Ni(OH)₂ by hydrogen in an oven at 300°C for 2 hrs, followed by passivation in hydrogen in a water-filled ves-
Fig. 1. Heat of hydrogen adsorption on Ni-black ($T_{\text{treatm.}} = 360^\circ C$) in the gas phase /1, 2/ and in the presence of chemisorbed water /3/ at 25$^\circ C$

The X-ray diffraction analysis showed 95%NiO+5%Ni mixture. The mixture was placed into an evacuated calorimetric cell ($10^{-6}$ Torr) and then reduced at $P_{H_2} = 10$ Torr and 300$^\circ C$ (1 hr). After reduction, hydrogen was desorbed from the nickel surface by a thermodesorption method ($V_{\text{des.}} = 4^\circ$/min), the cell was placed into the calorimeter for measuring the heat effects of water and hydrogen adsorption.

When operating with Ni-black, the reduction degree of nickel monoxide was found to depend on the temperature and time. After the first cycle of catalyst treatment, a part of nickel monoxide is not reduced, about 14% of the total amount of hydrogen being consumed for NiO reduction. Figure 1 shows the heats of hydrogen adsorption on Ni-black with (curve 2) and without (curve 1), taking into account the water formed in NiO reduction. The heat of hydrogen adsorption (kcal/mol), taking