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Ni-Cu/SiO_2 cogelled xerogel catalysts for selective hydrodechlorination of 1,2-dichloroethane into ethylene

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Hydrodechlorination of chlorinated organics is a particularly attractive alternative compared with incineration of wastes from the chlorine industry from both economic and environmental points of view. Several authors demonstrated the ability of bimetallic catalysts, composed of metals from Groups VIII and IB, to convert chlorinated alkanes selectively into less or not chlorinated alkenes. The purpose of this study is to measure catalytic activity and selectivities of 1,2-dichloroethane hydrodechlorination over Ni-Cu/SiO_2 cogelled xerogel catalysts and to study relationships between catalytic activity and surface properties of bimetallic catalysts. To understand the mechanism of hydrodechlorination of 1,2-dichloroethane on a supported alloy, the surface composition of Ni-Cu alloy is measured from H_2 chemisorption, XRD and TEM. Values obtained indicate a very pronounced surface enrichment with copper.

Samples containing various amounts of nickel and copper are xerogels prepared by a one-step sol-gel procedure, which consists in the cogelation of the silica precursor, tetraethoxysilane (TEOS), with organically substituted alkoxides capable of forming chelates with nickel and copper ions. The resulting alcogels were dried under vacuum at 80°C, calcined in air at 400°C, and finally reduced in hydrogen at 450°C. For each catalytic experiment, 0.11 g of catalyst pellets were tested. The temperature was successively kept at 200, 250, 300, 350 and 300°C.

While 1,2-dichloroethane hydrodechlorination over pure nickel mainly produces ethane, increasing copper content in bimetallic catalysts results in an increase in ethylene selectivity. Used alone, copper deactivates rapidly due to their covering by chlorine atoms. When nickel is present, it supplies hydrogen atoms for the regeneration of the chlorinated copper surfaces into metallic copper. The specific consumption rate of 1,2-dichloroethane decreases when copper loading increases. The turnover frequency, that is, the number of catalytic cycle per active site (nickel atom and its surrounding copper atoms) and per second, seems to be independent of surface composition of alloy particles.

Keywords: Nickel-copper alloy; xerogel catalysts; sol-gel process; hydrodechlorination