Effect of alloying on carbon formation during ethane dehydrogenation

The structure sensitivity of different transition metals in the hydrogenolysis, dehydrogenation, and coking reactions during ethane conversion has been investigated. The investigated metals, Ni, Ru, Rh, and Pd, are co-impregnated with Ag onto an inactive MgAl2O4 spinel support and tested in the conversion of ethane. A tendency is clear for all catalysts: In the first period of time 100% ethane is converted and roughly half of the carbon is converted into coke and deposited on the catalyst. The other half of the carbon is converted into methane. The active sites in the hydrogenolysis are blocked by coke during the initial period where after dehydrogenation of ethane is observed. It has previously been predicted in surface science studies that Ag covers the steps of certain transition metals. Here it is documented that the hydrogenolysis and coking reactions are significantly suppressed by co-impregnation of Ag and Ni. The effect of Ag is limited for Ru since the active sites are self-poisoned by carbon; nor for Rh/spinel is the effect observed, which is possibly due to island formation of Ag on the terraces of the Rh metal. A prolongation of the initial period with hydrogenolysis is observed for Ag-Pd/spinel due to an alloy formation of Ag and Pd at these conditions. From our results it can therefore be concluded that hydrogenolysis mainly takes place on the steps and kinks of the transition metal particles, dehydrogenation reactions mainly takes place on the terraces, and coking is significantly reduced by covering the steps sites by Ag. This important information can be used in designing new catalysts with improved selectivity and stability.
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