catalysts

Supporting Information

Pd+Al_2O_3-Supported Ni-Co Bimetallic Catalyst for H_2 Production through Dry Reforming of Methane: Effect of Carbon Deposition over Active Sites

Supporting information S1. Details specification and procedure of characterization technique

The prepared catalysts are studied using X-ray diffraction (XRD) miniflex diffractometer having Cu Kα radiation (Rigaku Corporation, The Woodlands, TX, USA) to understand the phases present in the catalyst. The instrument is operated at 40 KV and 40 mA from 5 to 90^0 at a scanning rate of 2 deg/ min. The AutoChem II unit by Micromeritics is utilized to measure the reducibility of calcined catalysts. For the analysis, 0.1 g of the sample is placed in the sampler holder and heated under pure argon at 150°C for 30 minutes, after which it is cooled to room temperature. The temperature is then increased from 25°C to 900°C at a rate of 10 K/min while being exposed to a 10% H_2/N_2 mixture at a flow rate of 40 ml/min. The volume of H_2 outlet is measured using a TCD detector. The temperature-programmed CO_2 desorption (CO_2-TPD) is measured using automatic chemisorption equipment, the Micromeritics Autochem II 2920, which also has a TCD detector. For this analysis, 50 mg of the sample is heated at 200°C for an hour under a helium flow to remove any adsorbed components and then cooled to room temperature. CO_2 adsorption is carried out at 50°C for 60 minutes in a gas mixture of helium and CO_2 at a flow rate of 30 ml/min. The TCD records the CO_2 desorption signals as the temperature is raised to 900°C at a rate of 10 K/min. To measure the amount of carbon deposition on the spent catalysts, Thermogravimetric analysis (TGA-51 by Shimadzu, Kyoto, Japan), is used, in this analysis, 10-20 mg of the spent catalyst is heated in the presence of nitrogen at a rate of 20°C/min.

Laser Raman (NMR-4500) Spectrometer (JASCO, Japan) was used to obtain Raman spectra of the spent catalyst samples. The wavelength of the excitation beam was set to 532 nm and objective lens of 100x magnification was used for the measurement. The laser intensity was adjusted to 1.6 mW for 10s exposure time at 3 accumulations. This was to protect the sample from being damaged by laser irradiation. Measurement was done in the range 1200-3000 cm^{-1} (Raman shift) and the spectra were processed using Spectra Manager Ver.2 software (JASCO, Japan).

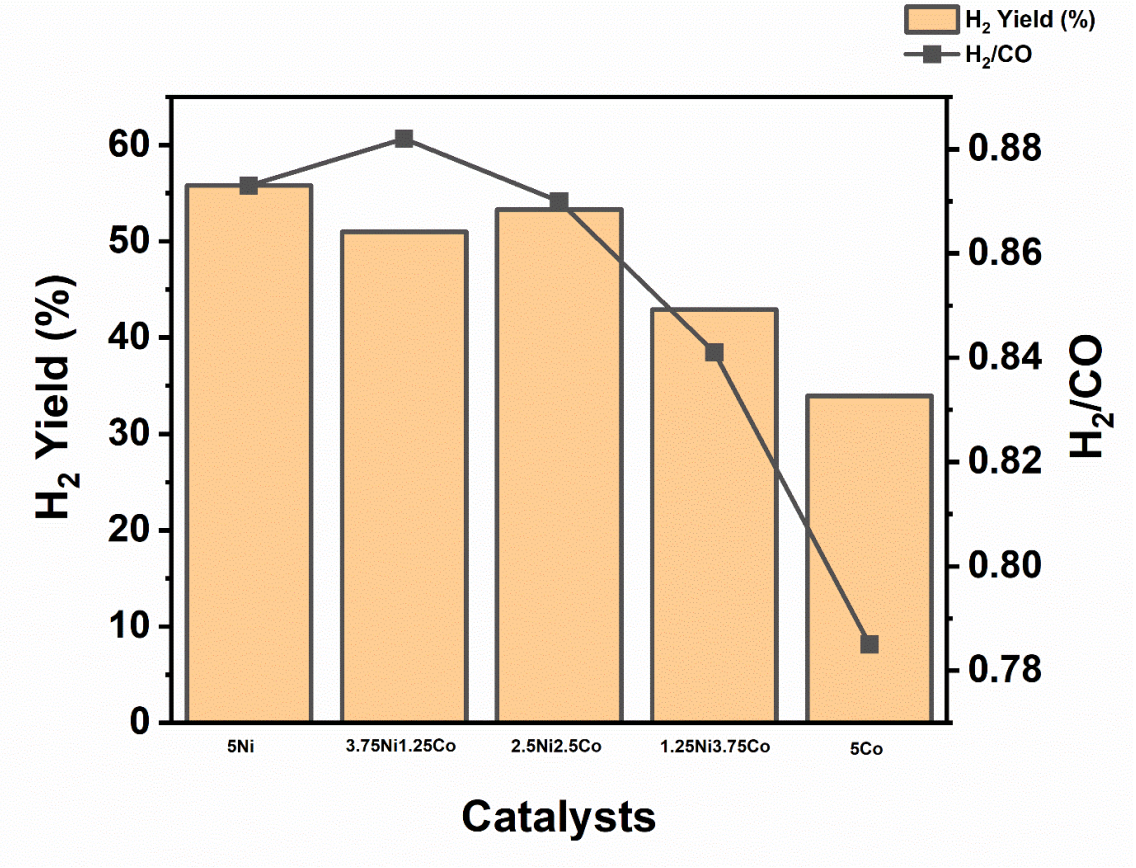

Figure S1. H_2-yield and H_2/CO ratio over different catalyst systems; 5 Ni ~ 5Ni//Pd+Al_2O_3 , 3.75Ni1.25Co ~ 3.75Ni1.25Co/ Pd+Al_2O_3, 2.5Ni2.5Co ~ 2.5Ni2.5Co/ Pd+Al_2O_3, 1.25Ni3.75Co ~ 1.25Ni3.75Co/ Pd+Al_2O_3, 5Co ~5Co/ Pd+Al_2O_3.

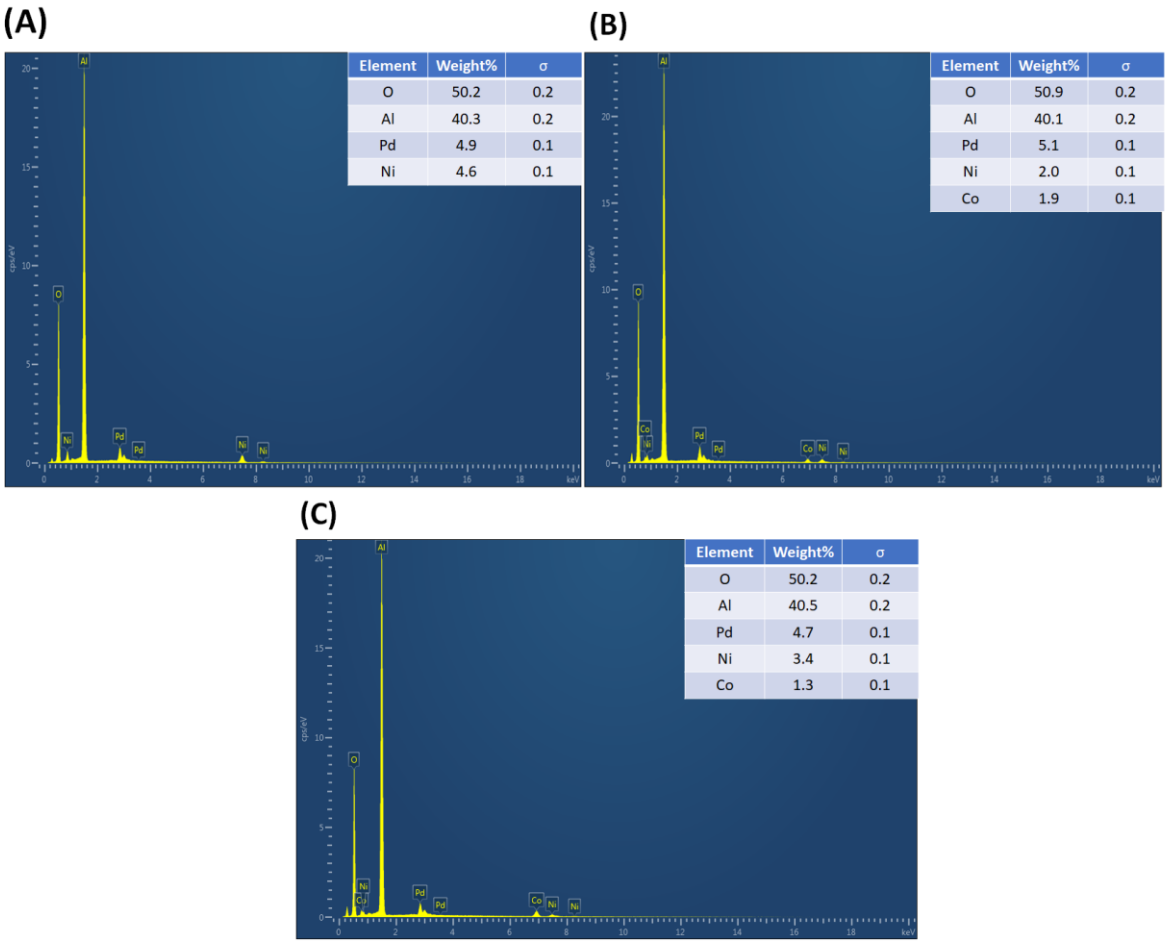

Figure S2. EDX profile of (A) 5Ni/Pd+Al_2O_3 (B) 2.5Ni2.5CO/Pd+Al_2O_3 (C) 1.25Ni3.75CO/Pd+Al_2O_3.