Reaction efficiency between hydrogen and carbon monoxide on a catalytic substrate of iron, nickel or its alloy

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Reaction of hydrogen and carbon monoxide on a catalytic substrate to form methane and water has widely been used to synthesize fuel and called the Fischer-Tropsch reaction (FT reaction). Typical conditions of the FT reaction for manufacturing application is a total gas pressure of 10^5-10^6 Pa with a ratio of H_2 / CO = 2 at 500-650 K together with a catalysis of Fe, Co or Ru[1]. Then, water-gas shift reaction has been occurred as a side reaction; carbon dioxide and hydrogen molecules form from carbon monoxide and water. The efficiencies of both reactions depend on the substrate, temperature, pressure and other conditions. Cobalt has most been used as a catalysis because of the lower activity of the side reaction [2,3]. Although the FT reaction has been used for long years, the atomic/molecular scale mechanisms that govern the FT reaction are still disputable [4]. Therefore, it is not obvious that the results of the reaction experiments are able to extrapolate to the actual solar nebula environment. Here we demonstrate the reaction rates in the solar nebula conditions (below 500 K and under 10^2 Pa) on the surface of cosmic dust particles, such as iron, iron-nickel alloys and nickel.
We developed an experimental system to test the catalytic chemical reactions in the temperature and pressure ranges of 50-800 K and 10^{-3}-10^3 Pa, respectively, using a metallic plate as a catalytic substrate. Our experimental system has a temperature-controlled substrate, a Fourier transform infrared spectrometer (FT-IR), and two quadrupole mass spectrometers (Q-MSs). FT-IR is able to measure the vibration modes of adsorbed and produced molecules on the substrate. Currently, several IR features has been detected at the temperature below 150 K. To identify the mass signal of produced methane and water in the Q-MSs spectra, deuterium was used instead of hydrogen. The intensity of the signal of masses 20 and 44 decreases as temperature decrease from 800 K. The mass 20 corresponding to D_2O and CD_4, which are first products in the Fischer-Tropsch type reaction, was detected. Simultaneously, mass 44 corresponding to CO_2 was also detected. In our presentation, the substrate dependence of the reaction efficiency will be presented.

References

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