Temperature dependence of reaction efficiency in the Fischer-Tropsh-type catalytic reaction on an iron substrate

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Fischer-Tropsch type catalytic reaction has been believed to be one of simplest and most fundamental formation processes of organic molecules, which dominantly occurred on the surface of cosmic dust particles, such as iron, magnetite, amorphous iron silicate and graphite, in the period from the late stage of molecular cloud to the solar nebula. Experimental approaches to find the environment, where catalytic reaction was progressed efficiently, have been attempted in laboratories [1-5]. In the experimental studies, organic molecules ranging from methane (CH_4), ethane (C_2H_6), benzene (C_6H_6) and toluene (C_7H_8), to more complex species such as acetone (C_3H_6O), methyl amine (CH_3NH_2), acetonitrile (CH_3CN) and N-methyl methylene imine (H_3CNCH_2) have been produced at temperature above 573 K and relatively high pressure (10^5 Pa). In case of actual environment in the early nebula environment, the temperature and pressure should be below 500 K and under 10^2 Pa, respectively. It is not obvious that the results of the reaction experiments are able to extrapolate to the actual early nebula environment. Therefore, we newly developed an experimental system to test the catalytic chemical reactions in the lower temperature (100-800 K) and pressure (10^{-3}-10^0 Pa) using an iron substrate. Our experimental system has a temperature-controlled substrate, a Fourier transform infrared spectrometer (FT-IR), and two quadrupole mass spectrometers (Q-MSs). Although FT-IR is able to measure the vibration modes of adsorbed and produced molecules on the surface, we have not been used it during the first experiment at higher temperature. We found a strong signal of mass 20 in the Q-MSs spectra in a continuous gas flow of a mixture gas of D_2 and CO. The intensity of the signal decreases as temperature decrease from 800 to 400 K and becomes weaker than the detection limit below 300 K. The mass 20 corresponds to D_2O and CD_4, which are first products in the Fischer-Tropsch type reaction. In our presentation, the detail results using iron substrate will be presented as a function of temperature.

References

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