Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS24-P05 会場:3 階ポスター会場 時間:5 月 1 日 18:15-19:30

低温低圧環境下における微粒子表面での触媒化学反応による有機分子生成実験に向けて
A New Experiment for Organic Molecule Formation by Catalytic Reactions on the Surface at Low Temperature and Pressure

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Abundant H_2, CO and N_2 gases react to be more complex molecules mainly on the cooled surface of cosmic dust particles in the molecular cloud and/or primitive solar nebula [1]. The production of organic molecules and subsequent evolution to organic materials in the solar nebula may contribute to the primordial organic system of the Earth. Catalytic chemical reactions are possible production pathway of organic materials in the solar nebula after the formation of simple molecules on nanometer sized cosmic dust particles in the molecular clouds. Experimentally, 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 using such as the Fischer-Tropsch type (FTT) and Haber-Bosch type (HBT) reactions on analogs of naturally occurring grain surfaces [2]. Previous studies were performed at higher-temperature (>573 K) and pressure (~1 atm) than the expected conditions in the solar nebula [3-6]. However, since the actual environment is at lower temperature and pressure, it is not clear whether the previous experimental results can be extrapolated to the solar nebula. Our group seeks to elucidate the reaction rates of chemical reactions including isotopic fractionation at lower temperature (100-500 K) and pressure (10^{-3}-10^{0}) and their contribution to the primordial organic system of the Earth.

We are constructing a vacuum chamber based on a new concept to conduct the experiments mentioned above. The chamber with a differential pumping system has a temperature-controlled substrate, a Fourier transform infrared spectrometer (FT-IR), and two quadrupole mass spectrometers (Q-MSs). The substrate has an iron or silicate thin film for FTT and HBT reactions and the FT-IR measures the vibration modes of adsorbed and produced molecules on the surface and the Q-MSs detect volatile and nonvolatile molecules, respectively. As a result, reaction rates of molecules such as H_2, CO, N_2 and NH_3 on iron or silicate substrate will be obtained as a function of temperature and pressure.

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キーワード: 有機分子, 触媒反応, 原始惑星系
Keywords: Organic molecules, Catalytic reactions, Protoplanetary system