Reproductive experiment of organic formation by catalytic reactions in the solar nebula

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At the transition phase from molecular cloud to the solar system, organic molecules on the surface of cosmic dust particles experienced environmental changing in wide range, i.e., increasing temperature and pressure. Then, some molecules released from the surface of dust and the others reacted to be more complex organic molecules by assistance of catalytic dust. ALMA is able to detect distribution profiles of sublimated molecules into gas phase in both of molecular cloud and extrasolar nebula with high spatial resolution and high sensitivity. Recent high-resolution proves are also able to analyze the fine composition of meteorite and stardust samples and finding many kinds of organic materials. These organics may contributed to the primordial organic system of the Earth. Unfortunately, however, there is no real evidence about the process of organic formation in a solid phase. Although some experimental studies have been performed using dust analogues, the elementary steps in molecular evolution in the environment from molecular clouds to nebulae are still uncertain.

Catalytic reactions such as the Fischer-Tropsch type and Haber-Bosch type reactions produce organic molecules efficiently on the surface of dust including iron at temperature above 573 K [1,2]. Recently, we developed a new experimental system to test the catalytic chemical reactions in the early nebula environment [lower temperature (100-500 K) and pressure (10^{-3}-10^{0} Pa)] using a substrate of magnesium silicate or iron. Figure 1 shows a photo of the system, which has a temperature controllable substrate made of gold. Silicate or iron with a thickness of submicron is deposited onto the substrate and used as a substrate for the catalytic reaction experiment. Molecules on the substrate are detected by a Fourier-transform infrared spectrometer (FT-IR). Released molecules into the gas phase detect by quadrupole mass spectrometers (Q-MSs). Here, we will show the preliminary results of the project.

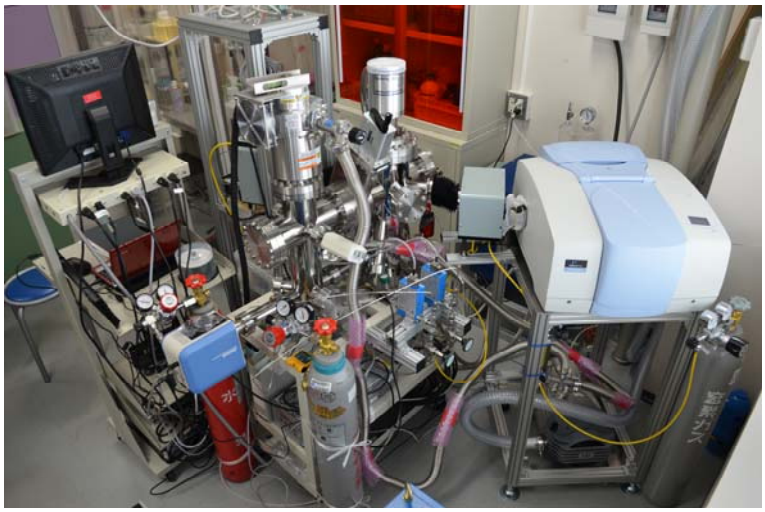

Figure 1: Photo of the newly developed system for catalytic reaction experiment. This system has differential pumping system, a temperature-controlled substrate (26-800 K), FT-IR, two Q-MSs and gas flow controller.

References

[1] H. G. M. Hill, & J. A. Nuth, 2003, Astrobiology 3, 291.

[2] J. A. Nuth, N. M. Johnson, & S. Manning, 2008, ApJ 673 L225.