Aqueous chemistry of formaldehyde and ammonia in the early Solar System

Y. KEBUKAWA[1]*, S. MISAWA[1], J. KAWAI[1], H. MITA[2], K. NANBU[3], T. OUCHI[3], Y. MURAMATSU[3], I. YODA[4], S. TACHIBANA[5] AND K. KOBAYASHI[1]

[1] Yokohama National University, Yokohama 240-8501, Japan (*correspondence: kebukawa@ynu.ac.jp)
[2] Fukuoka Institute of Technology, Fukuoka 811-0295, Japan
[3] University of Hyogo, Himeji 671-2201, Japan
[4] Tokyo Institute of Technology, Tokyo 152-8550, Japan
[5] Hokkaido University, Sapporo 060-0810, Japan

Simple molecules such as H_2CO and NH_3 were expected to incorporate into the planetesimals with water ice in the early accretion history. Cooper et al. [1] identified sugar-related compounds in carbonaceous chondrites, and speculated that these compounds, and possibly insoluble organic matter (IOM), were derived from interstellar H_2CO via the formose reaction. The spectroscopic data supported the hypothesis that IOM and refractory organics in comets may have formed through the condensation of interstellar H_2CO after planetesimal accretion, in the presence of liquid water in the early solar system [2,3]. The addition of NH_3 to the solution enhanced the rates of organic solid yields at lower temperatures and results in substantial incorporation of nitrogen into the organic solids [3,4].

We are now focusing on the liquid phases of the reaction products obtained from H_2CO and NH_3 with various analytical methods, e.g., electrospray ionization mass spectrometry (ESI-MS), X-ray absorption near edge structure (XANES), infrared (IR) spectroscopy and amino acid analyses using high performance liquid chromatography (HPLC). The analytical results showed that soluble fraction contain various carbohydrates (CHO molecules) and these with nitrogen (CHON molecules), and aromatic/olefinic C=C bond abundance increased with temperature. Acid hydrolysis of the solutions produced various amino acids up to four carbons. We also evaluate the effects of γ-ray as an energy source for chemical reactions. γ-ray is expected from decay of ^{26}Al which is considered as a heat source for aqueous activity in the planetesimals. Our preliminary results show that γ-ray induces different chemistry from heating experiments. We will discuss further the aqueous chemistry of H_2CO and NH_3 in the early planetesimals.

[1] Cooper *et al*. (2004) *Nature* **414,** 879-883. [2] Cody *et al*. (2011) *PNAS* **108**, 19171-19176. [3] Kebukawa *et al*. (2013) *ApJ* **771**, 19. [4] Kebukawa & Cody (2015) *Icarus* **248**, 412-423.