The Organics Exposure Experiment in the Tanpopo Mission: Space Exposure of Amino Acids and Their Precursors for 1-2 Years

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Since a wide variety of organic compounds have been detected in extraterrestrial bodies such as carbonaceous chondrites [1], extraterrestrial organic compounds have been regarded as important sources for the first life on the Earth. Chyba and Sagan [2] suggested that much more organics were delivered to the primitive Earth than meteorites and comets. It is difficult, however, to detect bioorganics in cosmic dusts if they are collected in the terrestrial biosphere.

We started the first astrobiology experiments in Earth orbit named the Tanpopo mission [3] in May 2015. The mission is composed of the capture experiment and the exposure experiment. In the capture experiment, dusts flying near ISS are collected by using aerogel. In the exposure experiment, microorganisms and organic compounds are exposed to space environments to test their survivability in space. The mission is carried out by utilizing an ExHAM (Exposed Experiment Handrail Attachment Mechanism) on the Exposed Facility of Japanese Experimental Module (JEM-EF) in the International Space Station (ISS). We have already recovered the samples exposed for one year in 2016, and those for two years in 2017. Here we report on preliminary results of organic exposure experiment.

We selected two amino acids (glycine and isovaline) and three amino acid precursors (hydantoin, 5-ethyl-5-methylhydantoin (EMHyd) and “CAW”. Hydantoin and EMHyd are possible precursors of glycine and isovaline, respectively. CAW contains complex amino acid precursors, which was synthesized by proton irradiation of a mixture of CO, NH_3 and H_2O [4]. All the organic materials used were labeled with ^{13}C. Aqueous solution of each of these materials was added to one of dimples on an aluminum plate, and dried. Then the surface of the materials was covered with hexatriacontane to avoid sublimation. Each plate for space exposure was covered with a SiO_2 window (I) or MgF_2 window (II). The same kinds of plates were prepared and space exposed without an optical window (dark control; III), stored in a JEM cabin controls (cabin control; IV), or stored in a laboratory on ground (ground control; V). Alanine thin film was used as a VUV dosimeter based on a dissociation experiment with a 172 nm excimer lamp [5].

Ground control experiments have been conducted in prior to the space exposure, and few expected low recovery of free amino acids (glycine and isovaline) and high recovery of amino acid precursors. Glycine and isovaline were analyzed by HPLC and GC/MS. Hydantoin and EMHyd were determined by GC/MS, and also by HPLC after acid hydrolysis.

We analyzed returned samples by HPLC and GC/MS. Isovaline was decomposed as expected, but glycine’s decomposition was less than expected. On the other hand, hydantoins were largely decreased even in dark control. The reason why glycine’s decomposition was less than expected seems to be hexatriacontane cut the shorter VUV (λ <160 nm) that is critical for glycine. Low recovery of hydantoins in the dark control is not clear at the present moment.

CAW gave glycine, alanine, b-alanine and other amino acids after acid-hydrolysis. Recovery of these amino acids in CAW was high enough as expected though it has large UV absorption at λ<160 nm. Complex precursors of amino acids could be robust molecules in space.

We are now discussing a new space experiments by using the ExHAM after 2019, which includes a successor of the Tanpopo organic exposure experiment.

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Keywords: Space dusts, Amino acids, Amino acid precursors, Solar ultraviolet light, Origins of life, The International Space Station

