Space Exposure of Amino Acids and Their Precursors in the Tanpopo Mission: Results and Future Prospects

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Abstract

A wide variety of organic compounds have been discovered in such extraterrestrial bodies as carbonaceous chondrites [1], comets and interplanetary dust particles (IDPs). Since some organic compounds found in the extraterrestrial bodies required for emergence of life, molecules that are used for the first terrestrial life could be synthesized in space. Then meteorites, comets and interplanetary dust particles could deliver them to the primitive Earth. Chyba and Sagan [2] suggested that cosmic dusts delivered much more organics 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 Tanpopo Mission, the first astrobiology space experiment, in 2015. The objective of the Tanpopo Mission is to understand bi-directional propagation of microorganisms and organic matter between the Earth and space. In other words, in the Tanpopo Mission, we examine whether life exists only on the earth by evaluating whether microorganisms can escape into space and whether organic matter can reach to the Earth from outer space.

As one of subthemes in this project, amino acids and their precursor compounds including complex interstellar organic matter analog were exposed to outer space by utilizing the International Space Station (ISS), and recoveries of these organics were measured to understand stability of organic compounds in space environments. Glycine (Gly), isovaline (IVal), hydantoin (Hyd), 5-ethyl-5-methylhydantoin (EMHyd) and complex interstellar organics analog (CAW: molecules synthesized by proton irradiation of a mixture of CO, NH3, H2O [3]) were selected as target molecules used in the Tanpopo organic exposure experiment. They were put in pits of aluminum substrates, dried, and covered with hexatriacontane (HTC) to prevent the sample from sublimation during exposure to space at the ISS.

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The aluminum plates with fused SiO2windows or MgF2windows were exposed to space for 1-3 years. For controls, the same kind of plates are placed on the back of the exposed plates (the dark control), stored in ISS cabin (the cabin control), or stored in the laboratory on ground (the ground control). Total solar UV dose was measured by using an alanine thin film dosimeter since decomposition ratio of alanine was correlated to UV dose.

The recovery ratio of Gly was higher than those of Hyd, Ival and EMhyd. The reason why recovery of Gly was higher is that HTC absorbs UV light with a wavelength of 160 nm or less, where Gly has limited absorption. CAW also showed higher recovery than Hyd, Ival and EMHyd though CAW has much stronger absorption than the others. Thus complex molecules like CAW could be robust sources for extraterrestrial amino acids.

We are now preparing Tanpopo follow-on missions. One of them would start summer, 2019, which contains exposure experiments, where two kinds of exposure panels will be used: Tanpopo-type panels with aluminum plates, and the "QCC-type" panels [4]. The former will be used to examine effect of HTC on the recovery of organics. The latter will be used direct exposure of organics with and without optical windows. Glycine and complex interstellar organics analog (CA: molecules directly attached to silica plate by proton irradiation of a mixture of CO and NH3) will be used in this experiment [5].

References: [1] Kvenvolden K. *et al.* (1970) *Nature 228*: 923-926. [2] Chyba C. and Sagan C. (1992) *Nature 355*: 125-132. [3] Yamagishi A. *et al.*(2013) *ISTS Web Paper Archive2013-k-49*: 1-7. [4] http://exoplanets.astron.s.u-tokyo.ac.jp/QCC/index_tanpopo2_qcc-type.html [5] Mita H. *et al.* (2019) *EANA 2019*.