

ISS/JEM曝露部利用実験たんぽぽ：有機物の捕獲と暴露



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地球上の生命の起源を考える上で、生物体を構成する有機物の起源を考えることは非常に重要である。特に、アミノ酸は、炭素質隕石などから検出されており、宇宙環境に広く分布しており、それらが地球生物の源となったと考えられている。しかしながら、検出されたアミノ酸は、遊離のアミノ酸として存在するのではなく、何らかの前駆体として存在していることは知られているが、その化学構造の詳細は明らかでない。また、生物体を構成するアミノ酸はL-体から成っているが、宇宙環境における光学異性体の分布に関しては未知点が多い。そこで、本研究では、宇宙空間より多量に降り注ぐ宇宙塵を生物汚染のない国際宇宙ステーションの暴露部で捕集し、その中に含まれるアミノ酸の組成と光学異性体比を明らかにすることと、アミノ酸前駆体を暴露し、アミノ酸前駆体の構造の違いにより地球に到達するまでの分解に変化があるのかどうかを見積もることとした。

TANPOPO
Analysis of Interplanetary migration of microbes, organic compounds concerning with origins of life on the Earth

Panspermia: Possible migration of life through space.
1) Collection of microbe
2) Survival of microbes

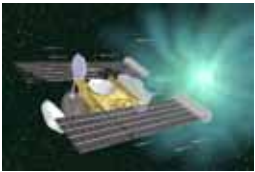
Chemical evolution: Transfer to Earth from extraterrestrial region
3) Collection of organic compounds
4) Alteration of organic compounds

Application:
5) Development of new aerogel
6) Monitoring of space debris

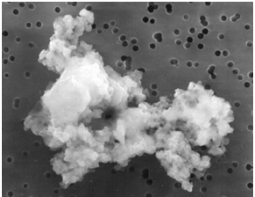
Interplanetary migration of organic compounds



Carbonaceous chondrites
Various kind of organic compounds were found in carbonaceous chondrites.
e.g. amino acids, nitrogenous bases, hydrocarbons . . .



Cometary dusts
Glycine was detected in the sample recovered from Wild 2 comet.
Many scientists thought that variety and abundant amino acids will be exist in comets from their chemical conditions, history, and simulation experiments.



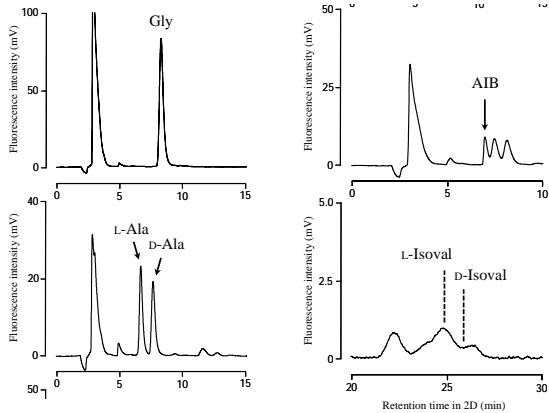
Interplanetary Dust Particles
IDPs are thought as a good transporter of organic compounds:
Large amounts of IDPs are delivered into the Earth.
Organic compounds in IDPs would not destroy at the impact.
But analyses of organic compounds are difficult without terrestrial contaminants.

Collection of IDPs with the ultra low density aerogel and analyses of organic compounds at LEO.

Possibility of organics in micron-scale particles.

There are two big problems for organic compounds analyses in the IDPs. One is the captured particles would be very small micron scale particles. Then, very sensitive analytical procedures should be prepared. Other is organic compounds should be survived from high velocity impact at the capture.

1. Amino acids in ca. 50 μm size meteorite particle



Our 2D-HPLC method for amino acid enantiomers separation technique is clearly applicable for amino acids analysis in the captured particles.

2. Spectrometric analyses of captured meteorite particles by our ultra low density aerogel with two-stage light gas gun

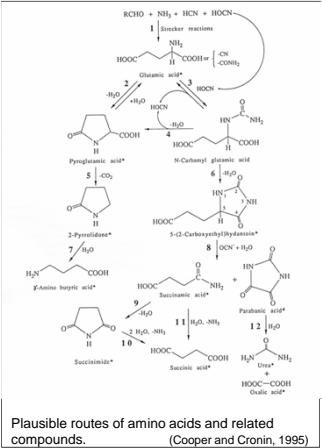
We also confirmed that organic compounds in the captured meteorite particles are not degradation.

Organic analyses would be performed without any problems.

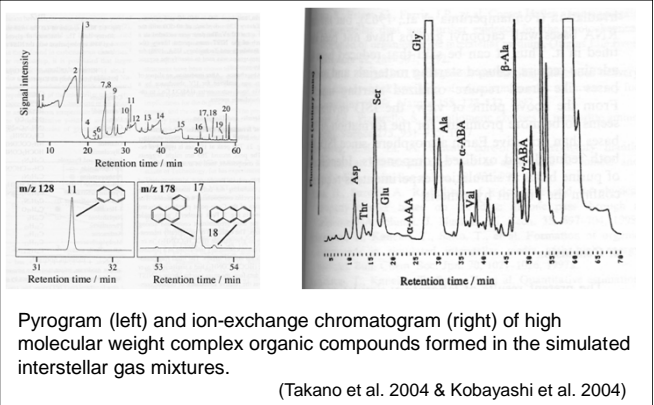
Amounts of free amino acids are minor components in the extraterrestrial samples.

Amino acids are existed as their precursors.

One plausible precursors are low molecular weight organic compounds.



Other plausible precursors are high molecular weight complex organic compounds.

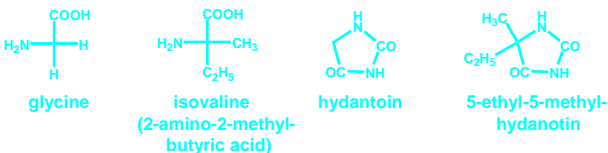


Alteration of organic compounds in space environments

Target compounds:
free amino acids glycine and isovaline

low MW amino acid precursors
hydantoin and ethylmethylhydantoin

high MW complex organic compounds (CAW)
Complex amino acid precursors produced by proton irradiation of a mixture of CO, NH₃ and H₂O



Alteration of organic compounds in space environments

Alteration forces at ISS orbit:

ultra violet light: Xe-excimer lamp (172 nm)
New SUBARU BL-6 (> 130 nm)

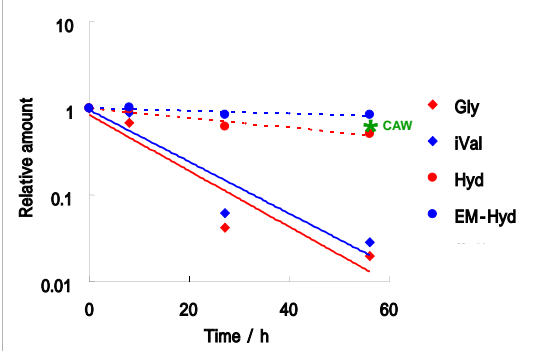
γ-ray: ⁶⁰Co at JAEA Takasaki
200 kGy (> 1000 yr)

heavy ion: Carbon ion (290 MeV) at NIRS
16 kGy (ca. 160 yr)

temperature: max. 80°C

UV irradiation experiment 1

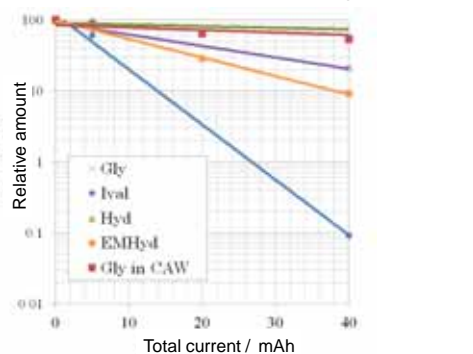
Xe-excimer lamp (172 nm) 4x10¹⁴ photon/cm²/s
(4d irradiation of this lamp = ca. 1yr @ ISS)



Hydantoin were more stable than free amino acids.

UV irradiation experiment 2

New SUBARU BL-6 (> 130 nm)
(1 d irradiation @ BL-6 = ca. 1.5 d @ ISS)



Precursors were more stable than free amino acids.

Estimated remains after 1 year exposure at ISS.

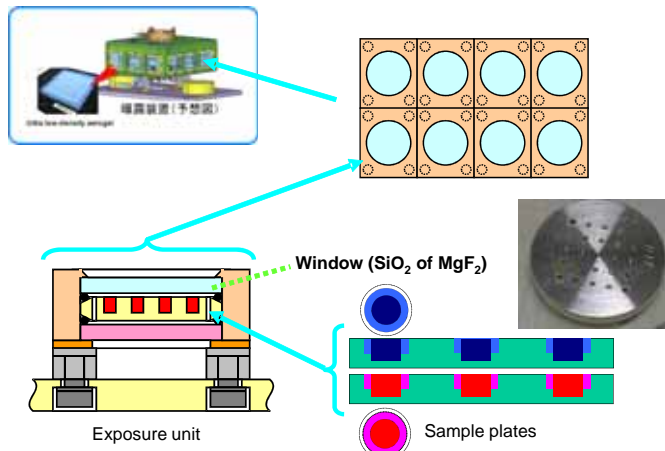
Estimated remains (%) after 1 year exposure at ISS orbit

	UV	γ-Ray	Heavy ion	Temperature	Total
Glycine	2 x 10 ⁻³	100	100	100	2 x 10 ⁻³
Isovaline	3 x 10 ⁻³	> 99	100	100	3 x 10 ⁻³
Hydantoin	29	100	100	100	29
Ethylmethylhydantoin	72	> 99	100	100	72
Complex organics (CAW)	36	100	100	100	36

Cosmic rays will not affect for alteration of amino acids their precursors.

UV is the largest effective energy source for alteration of amino acids their precursors.

Exposure equipment (conceptional)



TANPOPO mission

4) Alteration of organic compounds in space environments

To confirm the hypothesis that extraterrestrial organics played important roles in the generation of the first terrestrial life.

Free amino acids will be difficult to survive in the space environment.

Amino acid precursors will survive in the space environment.
Contribution of low MW precursors or high MW ones to the first life on the Earth will become clear in this experiment.