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たんぽぽ計画有機物曝露実験の現況報告

Current State of Organics Exposure Experiments In the Tanpopo Mission

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Abstract

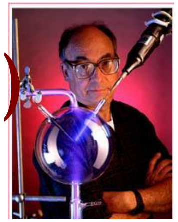
地球での生命の誕生において，地球圏外有機物の役割が注目されている。その地球への搬入に関しては，宇宙塵の寄与が大きいと推定されるが，宇宙塵中にアミノ酸またはその前駆体が存在するかどうかは不明である。たんぽぽ計画は，きぼう曝露部を利用し，地球生物圏に入る前の宇宙塵を採取して分析する捕集実験，アミノ酸関連分子の宇宙環境下での安定性を調べる曝露実験が含まれている。曝露実験では，グリシンなどのアミノ酸と，ヒダントイン，模擬星間複雑有機物(CAW)などのアミノ酸前駆体を用い，その安定性の比較を行う。

たんぽぽ計画は，2015年4月に装置が打ち上げられ，5月26日に実験が開始された。最初の捕集・曝露試料は2016年8月に地球に帰還し，現在，曝露試料の分析が進行中である。また，2－3年曝露した試料は，2017年および2018年に帰還する予定である。本ポスターにおいては，現在までに得られた結果と今後の予定について述べる。

It was suggested that extraterrestrial organic compounds played important roles in generation of terrestrial life. The Tanpopo Mission is the first astrobiology space mission utilizing the exposed facility of JEM, ISS. The mission includes collection of cosmic dusts and space exposure of amino acid-related compounds (free amino acids and their precursors) in order to examine possible delivery of extraterrestrial amino acid-related compounds by cosmic dusts (IDPs). The mission started in May, 2015, and the first sample returned to the Earth in August, 2016 after about 1 year’s exposure in space. The other samples will retune to the Earth in 2017 and 2018. Analysis of the returned samples is in progress.

Organic Compounds for the Generation of Life: Exogenous Delivery by Interplanetary Dusts (IDPs)

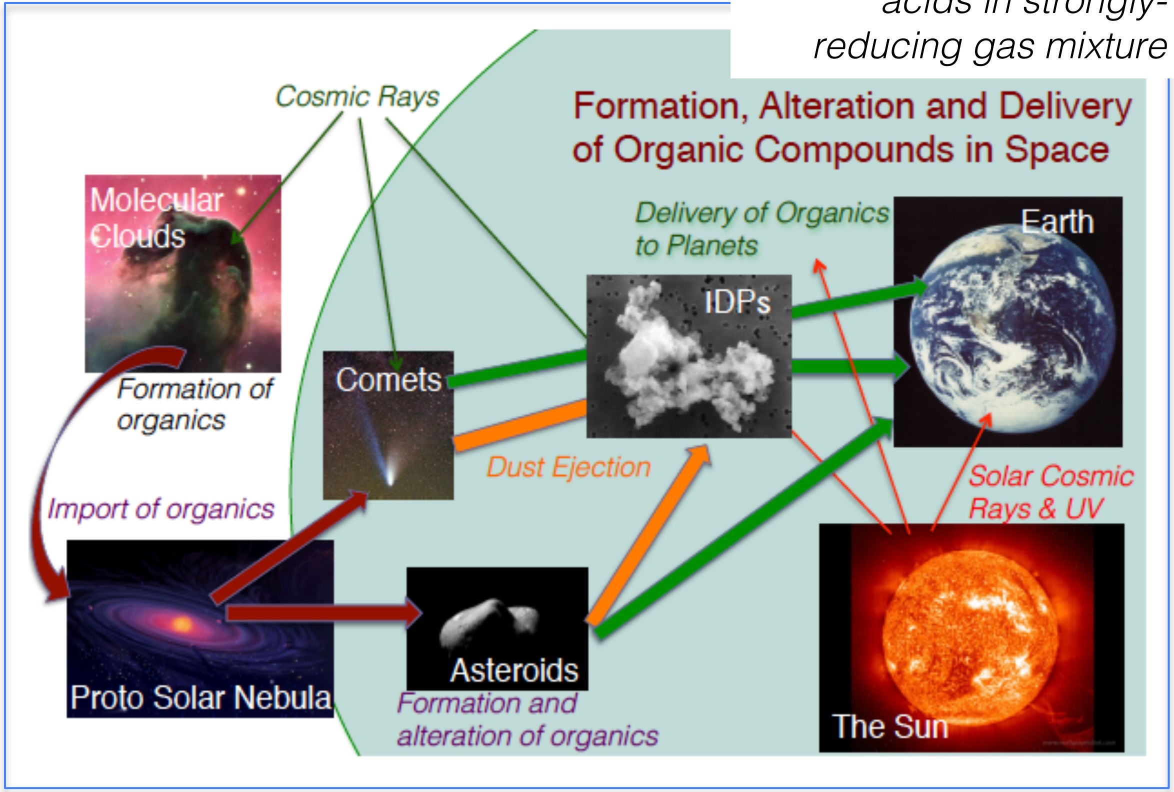
If primitive Earth atmosphere was not strongly reducing, endogenous production of organics (including amino acids) were restricted.



Formation of amino acids in strongly-reducing gas mixture

- ✓ Wide variety of organic compounds have been detected in extraterrestrial bodies.
- ✓ L-excesses of amino acids were observed in carbonaceous chondrites

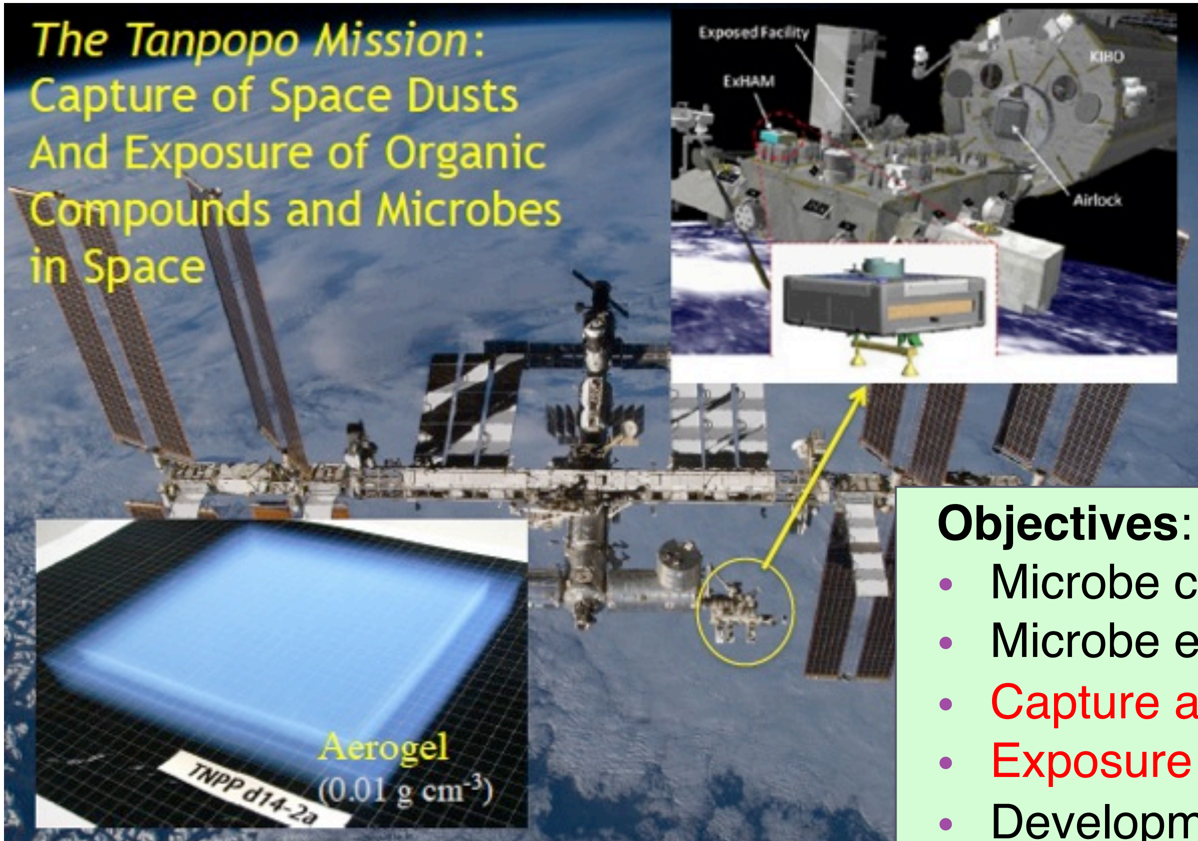
Extraterrestrial organics were essential for the generation of life on the Earth.

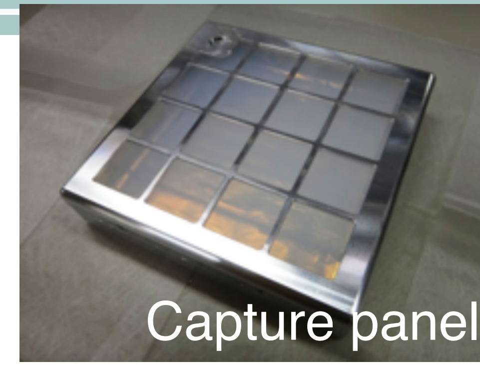


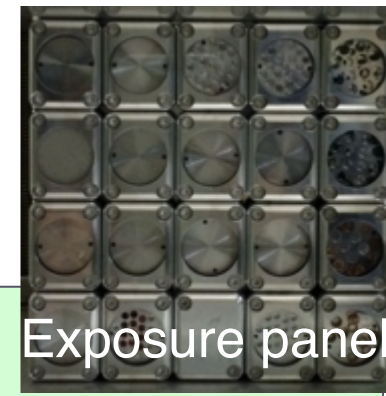
- ○ IDPs delivered more organics to to the Earth than meteorites and comets
- ○ IDPs delivered organics more safely than meteorite and comets

Objectives of the Tanpopo Mission

The Tanpopo Mission on the Exposed Facility of JEM, ISS







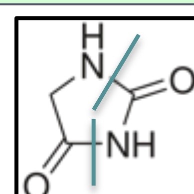
Objectives:

- Microbe capture
- Microbe exposure
- Capture and Analysis of IDPs
- Exposure of organics*
- Development of new aerogel
- Monitoring of space debris

*Amino acids and their precursors

Glycine	Hydantoin
Isovaline	5-Ethyl-5-methyl hydantoin

“CAW” (Complex amino acid precursors)



Hydantoin

CAW (imaginary) and glycine

Ground Simulations:

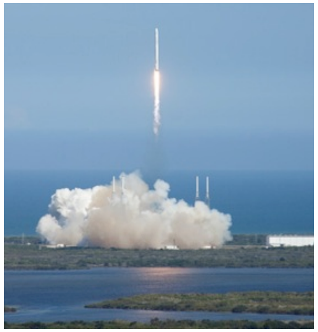
Evaluation of stability of organics by irradiation

	Estimated remains (%) after 1 year exposure at ISS orbit					
		UV	γ-Ray	Heavy ion	Temperature	Total
Free amino acids	Glycine	2 x 10^{-3}	100	100	100	2 x 10^{-3}
	Isovaline	3 x 10^{-3}	>99	100	100	3 x 10^{-3}
Amino acid precursors	Hydantoin	29	100	100	100	29
	Ethylmethylhydantoin	72	>99	100	100	72
	Complex organics (CAW)	36	100	100	100	36

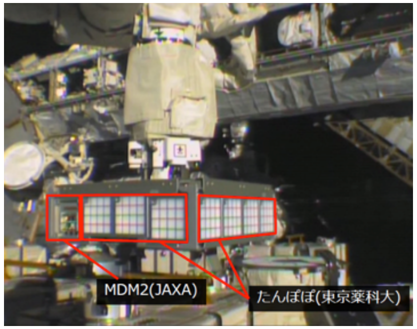
Estimated remains (%) after 1 year exposure at ISS orbit (Kobayashi et al., 2014)

Amino acid precursors would be much more stable than free amino acids in space.

Space Experiments:

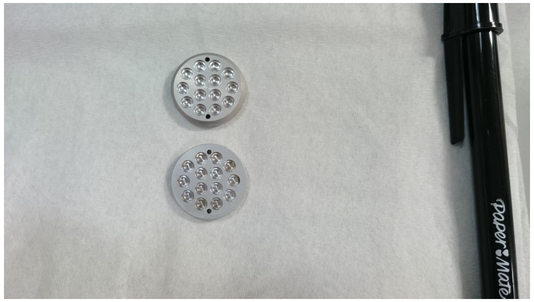


Launched in April, 2015



Space exposure started in May, 2015

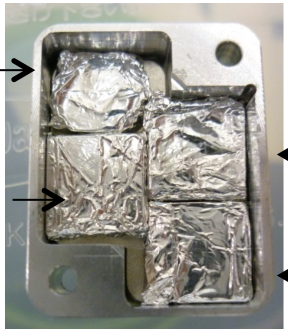
Returned to the Earth in August, 2016



Exposure plates after recovery

Experimental (2)

Radiation Dosimeters
- Optically stimulated luminescence dosimeter（OSLD）
- Silver activated phosphate glass dosimeter (RPLD)



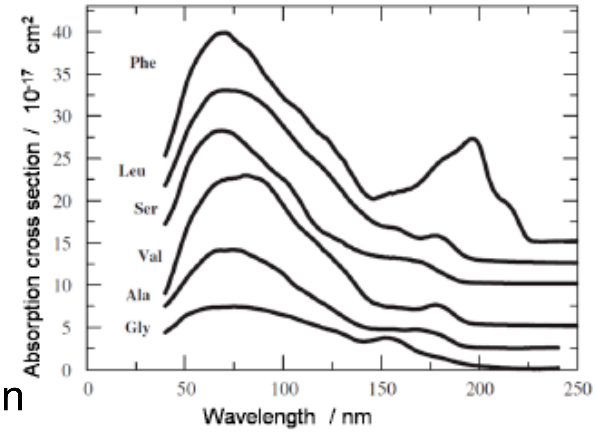
UV Dosimeters
- Alanine thin film dosimeter
- Alanine recovery was measured by FT-IR.

Preparation of the Exposure Samples (Amino acids & Their precursors)
1. 1.5 μL of 50 mM AA* aqueous solution (75 nmol) was injected to a hole of the exposure plate and dried.
2. 1 μL of sat. hexatriacontane in ethanol was injected over the dried ample, and then dried.

Recovery of the Exposure Samples
1. 1 μL of methanol was injected to the sample hole, and then moved to a glass tube (twice).
2. 1 μL of water was injected to the sample hole, and then moved to the same glass tube (10 times).
3. A set of the sample solutions was acid-hydrolyzed, and were subjected to a cation-exchange HPLC with post-column derivatization with OPA and N-acetyl-L-cystein (YNU). Another set was analyzed by GC/MS or LC/MS after derivatization (FIT).

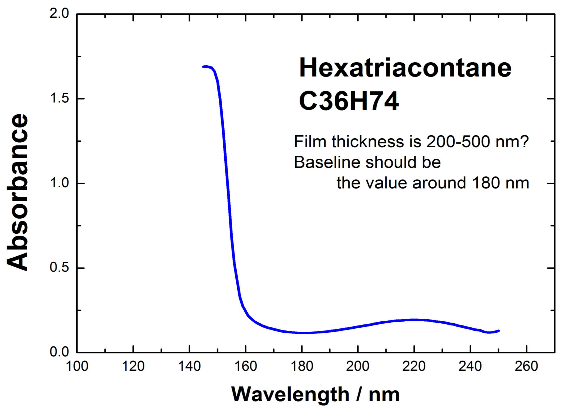
Preliminary Results & Discussion

Recoveries of Glycine and Its Precursors



VUV-UV spectra of amino acids (Nakagawa, 2009)

1. Glycine's decomposition was less than expected. The reason seems to be:
(a) Hexatriacontane cut the shorter VUV (λ <160 nm) that is critical for glycine.
(b) Samples were exposed to solar UV for restricted period during exposure.
2. Hydantoin's recovery was much lower than glycine. It seems to be due to higher absorption of near UV than glycine.
3. CAW gave high recovery of amino acids after exposure. Complex precursors of amino acids could be robust molecules in space.



VUV-UV spectrum of hexatriacontane

Summary

1. The capture and exposure experiments in *the Tanpopo Mission* was designed to confirm the hypothesis that extraterrestrial organics played important roles in the generation of the first terrestrial life, as well as examination of the hypothesis of *Panspermia*.
2. The experiments started in May, 2015, and the first sample returned to the Earth in August, 2016. The last samples will return in 2018.
3. Amino acids and their precursors (hydantoins and CAW (complex molecules synthesized by proton irradiation of possible interstellar media)) were exposed in space in the Tanpopo Mission.
4. Preliminary results showed that glycine showed high recovery than expected. It seems to be due to quite short exposure time and cut-off of shorter VUV by hexatriacontane.
5. CAW also showed high recovery after exposure. Contribution of extraterrestrial amino acid and/or their precursors to the first life on the Earth would become clear in this experiment.
6. Astrobiology experiments in Earth orbit of the next generation are now under discussion.

Acknowledgements

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