TANPOPO EXPERIMENT FOR ASTROBIOLOGY EXPOSURE AND MICROMETEOROID CAPTURE ONBOARD THE ISS-JEM EXPOSED FACILITY.

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Introduction and Mission Design: The origin of life is one of the most profound scientific quests to be challenged in this century. Yet we don't know if terrestrial life has been originated on the earth or in other parts of the solar system yet. On the other hand, it is known that "life precursors" or complex organic compounds are discovered both in molecular clouds nearby young stars and inside meteorites and cosmic dust, reaching to the earth from asteroids and comets.

Named after dandelion, a grass whose seeds with floss are spread by the wind, the TANPOPO is the first astrobiology experiment to be performed on a small pallet called "ExHAM" on the handrail of the ISS-Japan Experiment Module (JEM), or Kibo, Exposed Facility (EF) in the duration of 1-3 years starting from the 2014-5 timeframe, in order to test key questions consisted of the "quasi-panspermia" hypothesis, a theory for exogenesis origin of life and their transports among celestial bodies (Fig. 1) [1].

System Description: The TANPOPO employs blocks of ultra-low dense aerogels [2] on the Capture Panels (CP) that will be exposed and retrieved to capture impacting solid microparticles such as organic-bearing micrometeoroids and possible terrestrial particles in the low Earth orbit, for assessing the possibility of interplanetary transport of life and its precursors. By analyzing captured micrometeoroids in the aerogels, one can learn what kinds of extraterrestrial organic compounds in the pristine states inside micrometeoroids can be transported to the earth from primitive bodies and how they will be altered in outer space.

Once microparticles of terrestrial origin impacted into the CPs, one can test if terrestrial microbes (e.g., aerosols embedding microbial colonies) may be present, even temporarily and in "freeze dry" form in the low earth orbit altitudes. Also by evaluating retrieved samples of exposed terrestrial microbes and astronomical organic analogs on the Exposure Panels (EP), one can investigate their survivals and alterations in the duration of interplanetary transport.

Six Sub-Themes: The TANPOPO experiment consists of following six sub-themes (ST): 1) capture of microbes in space, 2) exposure of microbes in space, 3) exposure of organic compounds in space, 4) capture of organic compounds in micrometeoroids in space, 5) evaluation of ultra low-density aerogel developed for the Tanpopo mission, and 6) capture of space debris at the ISS orbit. Each will utilize one or more CP and EP samples from various pointing faces onboard the ExHAM as the ISS is a earth gravity gradient three-axis stabilized satellite (Fig. 2 and Table 1).:

(ST1:Terrestrial Life-bearing Aerosols Capture) Some research groups have conducted aerosol collections at high altitudes using balloons and aircraft. Microbes were isolated, suggesting their possible migration from ground to high altitudes. There has also been an unsolved discussion of how terrestrial microbial colonies embedded inside aerosols can escape to outer space. Potential candidates of the delivery mechanisms are energetic volcanic eruption, cloud-to-space electromagnetic discharges such as sprites, combined with the electromagnetic field around the earth, and occasional, large meteorite impacts. Microparticles captured in aerogels mainly on the leading and north faces will be microbiologically analyzed in order to test if the microbes may reach to the ISS orbit altitude. They will be observed under a fluorescence microscope in the presence of the DNA specific fluorescence pigment [3].

(ST2: Terrestrial Microbe Exposure) We will also expose UV-resistant and other terrestrial extremephile microbes on EPs and see how well they will survive in the low-earth orbit in a few years. We will analyze the survival of these microbes after transferring the exposed samples back to the ground laboratory.

(ST3: Astronomical Organic Analog Exposure) Life has evolved on the earth for ~4 billion years. Before the evolution of life, organic compounds were

needed to accumulate on the terrestrial surface. One of the major sources of the organic compounds on the earth is micrometeoroids. Thus analogs of organic compounds known to exist in molecular clouds and meteorites will be exposed on EPs in order to see how much these organic compounds may be modified by the space environment. In order to assess synergy effects of the space environmental factors, both radiometers and thermometers will be exposed together with the EPs and identical blank samples will be kept in the Kibo Pressurized Facility (PF) in the same duration as the TANPOPO exposure.

(ST4: Organic-bearing Micrometeoroid Capture) This sub-theme will try to detect organic compounds in micrometeoroids in space to discuss whether IDPs containing prebiotic organic compounds migrate among solar system bodies. Captured particles and their penetration tracks in the aerogels will be offered for various analyses after retrieval to Earth. Samples will be analyzed for mineralogical and organic characteristics. [4].

(ST5: Lowest Density Space-borne Aerogel Verification) The aerogel to be used in the TANPOPO experiment is uniquely designed to capture microparticles at hypervelocity at the least alteration, in order to protect for organic and biological signatures as much as possible. Thus the bulk density of the upper part of this "double-layered" aerogel is ~0.01g/cc. The lower part of the aerogel is ~0.03g/cc. The upper layer is expected to capture microparticles at the least peak heat, while the lower layer should withstand shock and vibration during the launch a rocket and landing a return capsule. Ground impact calibration tests have been performed but the TANPOPO flight will be its first space proven opportunity.

(ST6: Orbital Debris Flux Evaluation) Space debris is a real, existing threat to the sustainable space program. The CPs will also capture sub-mm sized space debris in the ISS orbit, which are impossible to be observed by remote sensing, in the entire duration of its exposure operation. Mainly from the leading face capture, post-retrieval analysis will allow one to study flux, sizes, impact direction, and approximate velocities of such micro-scale debris in the low earth orbit.

Initial Sample Analysis and Curation Plan: The TANPOPO-Initial Sample Analysis and Curation (ISAC) are planned and will be conducted by its Preliminary Examination Team (PET). The ISAC plan for CPs covers the receipt of retrieved samples, their initial inspection and documentation, processing and distribution of the samples for detailed analyses of each subtheme, cataloging for data archiving and sample storage. For initial inspection and documentation, they will map and measure aerogel penetration tracks and captured particles (e.g., incoming angle, track depth and track volume). Then they will process keystones or quickstones containing microparticles to be inspected further and their penetration tracks for allocation to respective sub-theme researchers, in accordance with their requests for the subsequent detailed analyses.

References: [1] Yamagishi A. et al. 2009. *Trans. JSASS Space Tech. Jpn.* 7: Tk 49-Tk 55. [2] Tabata M. et al. 2011. *Biol. Sci. Space*. 25: 7-12. [3] Yokobori S. et al. 2009. *Life Evol. Biosph*. 39: 377-378. [4] Kobayashi K. et al. 2009. *Orig. Life Evol. Biosph*. 39: 4.

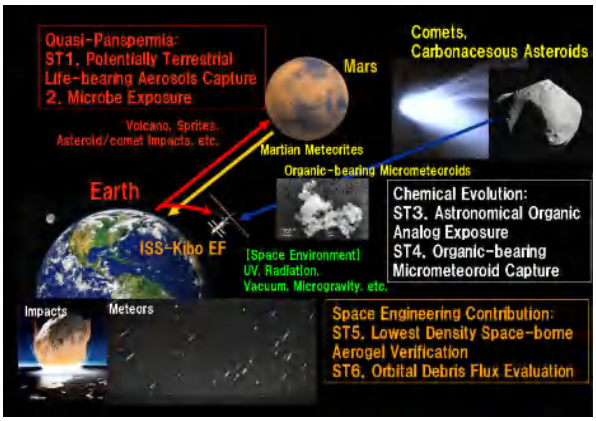

Fig.1 Concept of the Tanpopo Experiment

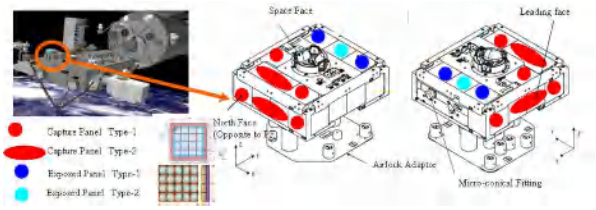

Fig.2. Tanpopo Configuration onboard the ExHAM attached to the ISS-Kibo Exposed facility

Table 1. Tanpopo Sub-themes and Experiment Conditions (*= Anti-Pressurized Facility face)

Sub-themes	Main Exposed Faces	Panels	Exchange frequency
ST1: Potentially Terrestrial Life-bearing Aerosols Capture	Leading, North*	Capture	Every year, x3 times
ST2: Terrestrial Microbe Exposure	Space	Exposure	1 tray after 1st, 2nd, 3rd years
ST3: Astronomical Organic Analog Exposure	Space	Exposure	1 tray after 1st, 2nd, 3rd years
ST4: Organic-bearing Micrometeoroid Capture	Space, North*	Capture	Every year, x3 times
ST5: Lowest Density Space-borne Aerogel Verification	Space, Leading, North*	Capture	Every year, x3 times
ST6: Orbital Debris Flux Evaluation	Leading, North*	Capture	Every year, x3 times