SILICA AEROGEL FOR USE IN COSMIC DUST COLLECTORS UTILIZED IN THE TANPOPO MISSION.
M. Tabata[1,2,*], H. Yano[1], H. Kawai[2], E. Imai[3], H. Hashimoto[1], S. Yokobori[4], and A. Yamagishi[4], on behalf of the Tanpopo WG[1], [1]Japan Aerospace Exploration Agency (JAXA), Sagamihara, Japan, [2]Chiba University, Chiba, Japan, [3]Nagaoka University of Technology, Nagaoka, Japan, [4]Tokyo University of Pharmacy and Life Sciences, Hachioji, Japan ([*] Corresponding author: makoto@hepburn.s.chiba-u.ac.jp).

Introduction: The Tanpopo mission is an astrobiological experiment to be conducted on the Japanese Experiment Module (JEM) on the International Space Station (ISS) [1]. The primary goal of the mission is to determine whether terrestrial microbes in dusts ejected by events such as volcanic eruptions can reach the low Earth orbit and whether interplanetary dust particles containing prebiotic organic compounds can migrate among solar system objects. In this mission, we will collect cosmic dusts using silica aerogels. After a one-year sampling period, the returned samples will be biochemically analyzed in our ground laboratories.

We developed an ultralow-density (0.01 g/cm^3) silica aerogel for capturing hypervelocity microparticles [2], which realizes an almost intact collection of cosmic dusts. Silica aerogel, a colloidal form of quartz (SiO_2), is an eminently suitable medium for cosmic dust sampling because of its light weight and optical transparency. Aerogel sample tiles were especially developed for the Tanpopo mission and were not contaminated by bacterial deoxyribonucleic acids (DNA) [3]. The aerogel material is formed as an integrated monolithic tile with different density layers and box-framing structures [4]. Being hydrophobic, it also suppresses age-related degradation caused by moisture absorption [5].

Because the aerogel-based cosmic dust collector will be mounted on the Exposed Experiment Handrail Attachment Mechanism (ExHAM), newly developed by the Japan Aerospace Exploration Agency, and equipped to the Exposed Facility using a robotic arm and airlock on the JEM, we developed a special aerogel holder [6]. The aerogel loaded in the holder must pass a vibration test for launch and a pressure test. We plan to expose multiple aerogels to several different sides of the ISS, both parallel and perpendicular to its direction of travel (i.e., the East, which is the direction of the ISS orbit, North, and zenith direction) in three-time annual exposures.

Development of Silica Aerogel for Capturing Cosmic Dusts: As a bread bode model, we first developed a simple two-layer aerogel with different densities at Chiba University. The aerogel consists of a 10.5 mm thick top layer of density 0.01 g/cm^3 and a 10 mm thick base layer of density 0.03 g/cm^3. The two layers are chemically combined as a monolithic tile in a wet-gel synthesis process [3], [4]. The low-density top aerogel layer is helpful for capturing cosmic dusts more or less intact. The higher density base layer functions to increase the strength of the whole aerogel tile and to surely capture high-energy cosmic dusts as well. In 2011, we conducted a mass production test of the two-layer aerogels in contamination-controlled environments. A total of 126 aerogel tiles were manufactured, and as a result, 106 undamaged aerogels were successfully obtained (i.e., a 84% yield) [6].

We developed a box-framing aerogel by redesigning density configuration and tile size so that it passes vibration tests for rocket launching. The outer size of an aerogel holder called as a capture panel was determined to be 100 × 100 × 20 mm^3, and a prototype panel was fabricated. The panel lid has grids to prevent the aerogel from escaping the panel and to ensure the safety of the ISS crew. Vibration tests revealed that the simple two-layer aerogel was seriously damaged by the panel grids. To resolve this, we designed the box-framing aerogel as an engineering model (Fig. 1). The top layer of density 0.01 g/cm^3 is surrounded by the base frame of density 0.03 g/cm^3 on not only the bottom surface but also the four sides. The box-framing aerogel is fixed in the panel by compressing only the base frame edges with the lid. The thickness of the 0.01 g/cm^3 top layer is designed not to touch the grids. The box-framing aerogel passed vibration tests for rocket launching and a depressurization and repressurization test [6].

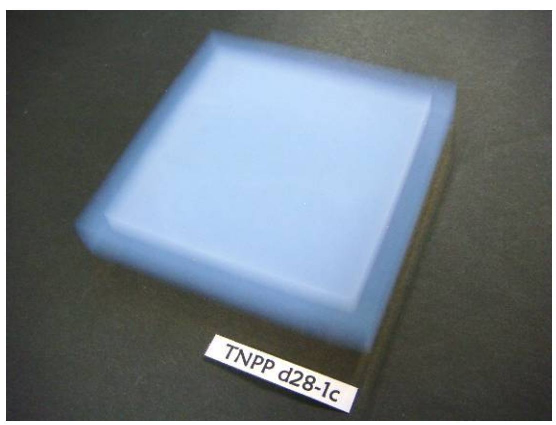

Fig. 1: Prototype of the box-framing aerogel, consisting of a 0.03 g/cm^3 base frame and a 0.01 g/cm^3 top layer.

We have conducted mass production of box-framing aerogels in 2013. A special polystyrene case was made for molding the base frame in the wet-gel synthesis process. It has taken 3 months to produce a total of 72 aerogel tiles. 60 out of 72 aerogels were manufactured strictly in contamination-controlled environments. The others were not treated in contamination-controlled environments; however, they can be used in laboratory tests. At present, measurements of the produced box-framing aerogels are ongoing.

Conclusion: We are developing silica aerogels for use in the cosmic dust collectors utilized in the Tanpopo mission. A procedure for manufacturing aerogels in contamination-controlled environments was established. A box-framing aerogels was designed to withstand vibrations during rocket launching. Mass production of box-framing aerogels has been performed in 2013. In this paper, we present the recent development of aerogels for the Tanpopo cosmic dust collectors.

References: [1] Yamagishi A. et al. (2009) *Trans. JSASS Space Tech. Japan, 7*, Tk_49–Tk_55. [2] Tabata M. et al. (2010) *Nucl. Instr. and Meth. A, 623*, 339–341. [3] Tabata M. et al. (2011) *Biol. Sci. Space*, *25*, 7–12. [4] Tabata M. et al. (2005) *Conf. Rec. on IEEE Nucl. Sci. Symp. and Med. Imaging Conf.*, 816–818. [5] Tabata M. et al. (2012) *Nucl. Instr. and Meth. A*, *668*, 64–70. [6] Tabata M. et al. (2013) submitted to *Trans. JSASS Aerospace Tech. Japan*.