COSMIC DUST CAPTURE SIMULATION EXPERIMENTS USING SILICA AEROGELS,

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INTRODUCTION: The development of low-density porous media chemically and structurally appropriate for the collection and recovery of interplanetary dust is a necessity for the Space Station Cosmic Dust Collection Facility and other analogous facilities. We and others have previously reported results of preliminary impact experiments simulating the capture of interplanetary dust into low-density silica aerogel [1,2]. Here we report results of (1) development of less-dense, cleaner silica aerogels, (2) structural and trace element analyses of silica aerogel, and the silica melt material produced during typical impact experiments and (3) additional impact experiments using monomineralic projectiles.

SILICA AEROGEL DEVELOPMENT: Although earlier attempts to make transparent silica aerogels were thwarted by a persistent degradation of optical clarity at bulk densities below 0.04 g/cc, transparent silica aerogel monoliths have now been successfully manufactured with densities down to 0.01 g/cc. The key to the manufacture of silica aerogels with required purity lies in the use of very pure precursor materials, the methanol extraction process employed, and better controls on autoclave seal and gasket materials. Careful attention to these factors has permitted production of silica aerogels with 0.4 wt.% hydrogen and less than 0.06 wt% carbon. These latter materials are hydrophilic, although this property may not be extremely detrimental considering their planned use.

STRUCTURE AND COMPOSITION: We have succeeded in imaging silica aerogel samples in the TEM. We prepare samples by impregnation using the epoxy MBED-812, followed by ultramicrotomy. Imaging verifies previous studies; silica aerogel consists of loosely bonded, nanometer-sized "balls" of silica. We saw no evidence of long-range structural order or large pores in material with a density of 0.12 g/cc. We are continuing our studies with lesser dense samples. We also investigated some of the opaque, white silica "droplets" typically produced during impact experiments as projectiles penetrate and compress silica aerogel targets. This material typically coats projectile residue. HRTEM imaging reveals that these "droplets" actually consist of welded, 50-200 nm-sized, rounded silica grains with considerable long-range order. This probably indicates that the particle capture process (at least at laboratory impact velocities of 5-7 km/sec) induces "melting" and subsequent crystallization of the originally "amorphous" aerogel.

We have also performed trace element analyses by INAA of two samples of silica aerogel, 0.12 g/cc produced by Henning AG and 0.06 g/cc manufactured at Lawrence Livermore Lab. The former

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material contains Fe (60 ppm), Sn (4 ppm), Br (2 ppm), Zn (0.3 ppm), Cr (0.2 ppm), Sb (10 ppb), Co (8 ppb) and Sc (60 ppt). The latter sample contains Rb (12 ppm), Na (3.4 ppm), Zn (0.4 ppm), Br (0.2 ppm) and Au (10 ppb). The Sn, Au and Zn are most likely traceable to autoclave materials, and Br to the solvents used, but the source of alkalies is unknown. Both of the aerogels are very pure materials. Even if impacting particles were mixed with silica aerogel in amounts many times their initial mass, bulk trace element analyses would not be greatly affected.

INTERPLANETARY DUST COLLECTION SIMULATION EXPERIMENTS: We have previously reported the results of impact experiments using polymineralic, simulated interplanetary dust aggregates measuring 1 mm in diameter and containing forsterite, pyrrhotite, enstatite, calcite and graphite [1]. We have now completed a series of impact experiments using silica aerogels with densities of 0.12 to 0.02 g/cc, and 100 um-sized monomineralic grains of forsterite, pyrrhotite and calcite, chosen for their varying physical properties and relevance to interplanetary dust studies. The mineral grains were "shotgunned" into the silica aerogel targets at velocities of 5, 6 and 7 km/sec. As previously described [1,2], small impacting grains bore into silica aerogel, producing gently curving penetration "tracks". Following each experiment we measured the track lengths, and excavated the projectile residues for TEM characterization.

Holding projectile and target density constant, we observe that track lengths roughly vary directly with velocity. For example, we observed that forsterite track lengths in 0.12 g/cc aerogel are 2-5.5, 2-5 and 3-6 mm for 5.1, 6.3 and 7.1 km/sec, respectively. In a similarly intuitive manner, with projectile density and velocity constant, track lengths were observed to roughly vary inversely with target density. Thus for forsterite accelerated to approximately 7 km/sec, we observed track lengths of 3-6, 5-18 and 8-22 mm in aerogels of densities 0.12, 0.04 and 0.02 g/cc, respectively. The extreme variability of track length within a single experiment demonstrates that track length is not a reliable indicator of projectile velocity [3]. Also, the curving nature of most tracks probably precludes their use as rough trajectory sensors.

Recovered projectile residues from these experiments were typically highly brecciated, locally devolatilized and melted, and welded together with fractured and melted aerogel fragments. However, crystalline domains remained in all residues. A few projectiles were found to have survived largely intact. The recovery of olivine and pyrrhotite residues was far better than that for calcite, consistent with known shock behavior [4,5].

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