

PURITY & CLEANNES OF AEROGEL AS A COSMIC DUST CAPTURE MEDIUM

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The capability for capturing micrometeoroids intact through laboratory simulations [Tsou 1988] and in space [Tsou 1993] in passive underdense silica aerogel offers a valuable tool for cosmic dust research. The integrity of the sample handling medium can substantially modify the integrity of the sample. Intact capture is a violent hypervelocity event: the integrity of the capturing medium can cause even greater modification of the sample. Doubts of the suitability of silica aerogel as a capture medium were raised at the 20th LPSC [Gibson 1989], and questions were raised again at the recent Workshop on Particle Capture, Recovery, and Velocity Trajectory Measurement Technologies. Assessment of aerogel's volatile components [Hartmetz 1990] and carbon contents [Gibson 1991] have been made. We report the results of laboratory measurements of the purity and cleanness of silica aerogel used for several Sample Return Experiments flown on the Get Away Special program.

Silica aerogel is very suitable for cosmic dust collection and can be easily cleaned to meet biogenic sample requirements. In fact, the purity and cleanness of silica aerogel fabricated at the Jet Propulsion Laboratory (JPL) handled under normal laboratory conditions were found to be comparable to silicon wafers produced for the semiconductor industry under strict clean room handling procedures. Silica aerogel has been shown to be the most suitable nonobstrusive elemental and biogenic intact sample capture medium.

EXPERIMENT A 10 cm x 10 cm x 1 cm piece of 20 mg/ml JPL silica aerogel taken from the fabrication lot flown on STS-57 was cut into smaller pieces (~ 1 cm x 1 cm x .2 cm). One piece was heated at 400°C for two hours. One piece with the internal surface and one with the external surface were mounted in separate sample holders under a normal laboratory environment. Charles Evans & Associates' Time-of-Flight Secondary Ion Mass Spectrometry (TOF-SIMS) and X-ray Photoelectron Spectroscopy (XPS) instruments were used to analyze the aerogel. TOF-SIMS makes use of a microfocused pulsed primary ion beam to sputter the top surface layer of the sample. The secondary ions produced are extracted and injected into a specially designed time-of-flight mass spectrometer. The mass sensitivity range is typically 0 to 5000 atomic mass units at relatively high mass resolutions, > 3000. An image of the lateral distributions of the secondary ions can be generated at spatial resolutions of less than 1 μm. XPS irradiates the sample with Mg or Al X-rays to cause the ejection of photoelectrons. The electron binding energies are used to identify the elements and, in many cases, the valence state(s) or chemical bonding environment of the detected elements.

RESULTS The TOF-SIMS positive ion spectra of the heated, unheated internal and external surfaces of the JPL aerogel are shown in Figures 1a, b & c respectively. The total integral counts were 1,252,803, 1,595,436 & 2,316,377 with acquisition times of 14.6, 15.3 & 15.0 minutes respectively. Figures 1b & 1c show the results of handling with vinyl gloves, wax papers, polyethylene bubble wrap and room contamination. Figures 1a and 1b show that heating pyrolyzed nearly all of the organic components. The cleanness of aerogel is compared to a typical silicon wafer as shown in Figure 2. The JPL silica aerogel is quite pure and clean. The binding energy of the heated sample with Mg X-ray is shown in Figure 3. The sample plane was 45° to the spectrometer with a total acquisition time of 19.7 minutes. XPS reaffirms that the aerogel is as clean as silicon wafer having been exposed to air.

FINDINGS With proper purification of raw materials and due care, silica aerogel can be made very pure. The heating in the aerogel critical extraction fabrication renders it inherently clean. With post heat processing, silica aerogel can be made essentially free from organic contamination to enable the preservation of captured biogenic elements and compounds. TOF-SIMS can be an excellent technique to analyze organic and inorganic particles captured in aerogel nondestructively even down to micron size.

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