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# EFFECTIVENESS OF INTACT CAPTURE MEDIA

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The possibility of capturing cosmic dust at hypervelocity has been demonstrated in the laboratory [Tsou 1988] and in the unintended Solar Max spacecraft [Bradley 1986]. This technology will enable a comet coma sample return mission and be important for the Earth orbital cosmic dust collection mission, i.e., the Space Station Cosmic Dust Collection Facility.

Since the only controllable factor in an intact capture of cosmic dust is the capturing medium, characterizing the effectiveness and properties of available capture media would be very important in the development of the technique for capturing hypervelocity cosmic dust intact. We have evaluated various capture underdense media for the relative effectiveness for intact capture.

## Underdense Media

Among the readily available underdense media evaluated thus far, organic polymer foams and inorganic aerogel hold the best promise for intact capture. To date, the polymer foam seems to offer higher capture efficiency while aerogel offers straightforward extraction of even submilimeter dust grains. Aerogel is transparent, a tremendous advantage over polymer foams which are opaque. Locating micrometer sized particles on a surface is difficult enough for a large collection surface area; finding such a particle in an opaque solid can be a monumental task. Since the ultimate objective is to extract and analyze the captured particles, the effectiveness of an intact capture medium must be selected based upon the degree of intact capture as well as the extractability.

One of the better capturing polymer foams is polystyrene emulsion foam in ringlet structures. The bulk density ranges from 60 to 100 mg/ml with rings like structure about 10 um in size. It is near beige in color with powdery pieces that come off when handled. The second polymer foam is phase separated polyacrylonitrile foam in a flake like structure. The flakes are a few microns in size with a density of 45 mg/ml. The color is also off white and opaque. Aerogel is made from tetrametoxysilane with about 5 nm sized spherical clusters. The 50 mg/ml aerogel we used is base catalyzed with a slight tinge of white smoke color when viewed from a distance. On closer inspection, it is transparent, especially backlighted.

## Intact Capturing Efficiency

In order to make quantitative comparisons among the capture media, consistent and reproducible hypervelocity launches were required. With the NASA Ames Vertical Gun, the highest reproducible speed is about 6 km/s with a 1.6 mm aluminum projectile. We selected the standard Ames aluminum 1.6 mm polished spherical projectile to evaluate all media. All experiments were performed in a vacuum about 5 mm Hg. Since the large projectile produces long track lengths about 20 cm and because we were restricted by the amount of custom foams available, limited number of experiments were performed for each medium.

Intact recovery results for the three media are shown in Figure 1 and compared to a commercially available polyethylene microcellular foam (in solid line) with a bulk density of 28 mg/ml and a 100 um polygon cellular structure. Projectile mass recovery refers to the mass of the captured intact projectile as compared to the original mass. For 1.6 mm aluminum projectiles, polystyrene foam produced the highest mass recovery. Polyacrylonitrile foam was second highest. Aerogel captured somewhat less mass than our standard polyethylene foam. However, based upon the shape of the recovered projectiles, polyacrylonitrile demonstrated the best projectile shape preservation, with only frontal erosion and no diameter change as shown in Figure 2. Projectiles recovered in aerogel revealed a somewhat conical frontal surface with hammered facets. Polystyrene produced the most deformed projectile, evident in the increased diameter of the recovered projectile. Further analyses should reveal the actual mechanisms that produced these changes.

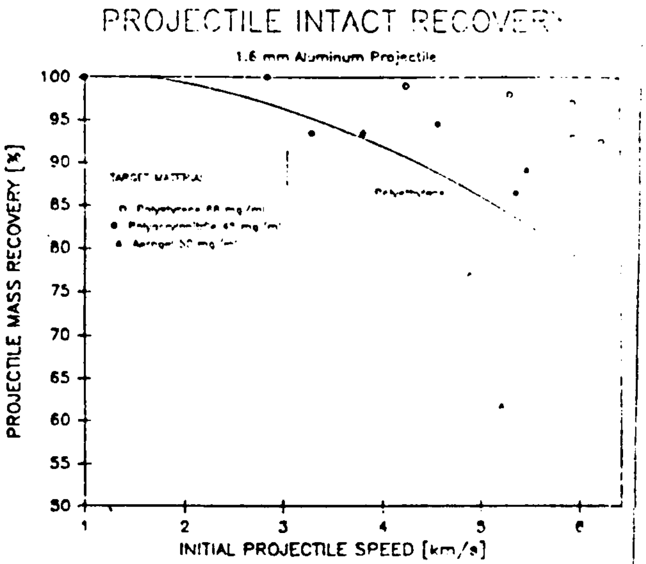


Figure 1. Intact Recovery

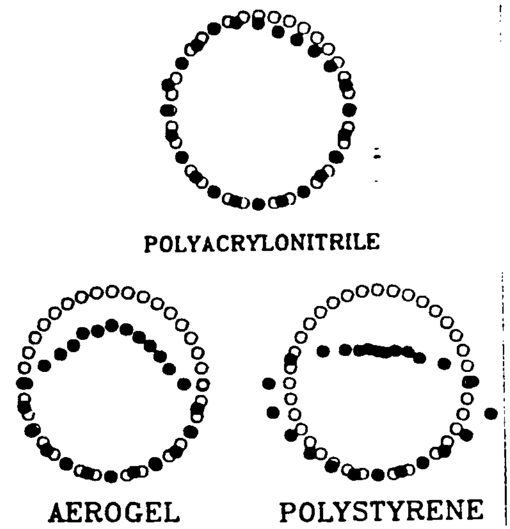


Figure 2. Recovered Projectiles

Projectile Extractability

Since polystyrene foam is opaque to light, captured projectiles can be isolated only by the entry holes. Without being able to see the actual projectile, the actual location and extraction will have to be done by trial and error. A precisely controlled manipulating device with x-ray such as CAT scaner would make location and extraction easier. One caution in extracting projectiles in all underdense media is the possibility of disrupting adjacent projectiles. From the point of view of projectile extractability, polystyrene foam presents the most challenge.

Polyacrylonitrile is also opaque, but since the polymer is not cross linked, the foam can be dissolved in solvents. Finding projectiles in this foam requires, as mentioned above, by entry holes. A parallel pipet centered about the entry hole can be cut from the foam and placed on a glass slide. When the proper solvent is placed on the cut foam, the foam will turn transparent and reveal the captured projectile (including any fragmented pieces). The dissolved foam forms a layer of transparent acrylonitrile. The slide can be furthered processed for SEM or microtome. In the worst case, an entire piece of foam can be dissolved, separating all captured particles.

Particle location is straightforward in aerogel even for micrometer sized particles, since the track diameter can be more than 10 times the particle diameter. Since the captured particles can be viewed under optical microscope, extraction can be selective. The current extraction method is to saturate the entire aerogel with epoxy first. When the aerogel softens, sections can be cut and separated. Once separated, the isolated particle can be further processed for SEM or TEM.

Findings

The effectiveness of different intact capture media vary respective to different criteria. Although high intact mass recovery is certainly desirable, the condition of recovery and the ease of particle location and extraction need be considered in determining media for specific applications. One more factor to be considered is the stability of these capture media in a space environment, especially for long duration exposure as in the Space Station Cosmic Dust Collection Facility or other space missions.

Acknowledgement

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References

Tsou, P., et al, LPSC 19, 1205 (1988), Bradley, J. et al, LPSC 17, 80 (1986).