

STARDUST AEROGEL - A NOBLE GAS EXPERIMENT. R. K. Mohapatra¹, S. Herrmann², U. Ott^{2,3}, A. Westphal⁴, and I. D. Clark¹. ¹University of Ottawa, Ottawa, K1N 6N5, Canada (ratam.mohapatra@uottawa.ca), ²Max-Planck-Institut für Chemie, D-55128 Mainz, Germany, ³University of West Hungary, H-9700 Szombathely, ⁴University of California at Berkeley, Berkeley, CA 94720, USA.

Introduction: Silica aerogel is a highly porous material that was used for capturing particles from comet *Wild 2* in NASA's Stardust mission [1]. The motivation for the present study is twofold. For one, the high porosity (density ~ 5 to 20 mg/cc [2]), of aerogel makes it suitable for gas adsorption and separation in noble gas mass spectrometry. Second, since the material has flown through the comet's atmosphere for ~ 6 h, it is hoped that it might have trapped some of the cometary gases [3].

Here we present preliminary results from our experiments that address noble gas desorption properties and noble gas concentrations in Stardust aerogel.

Experiment: Samples for the present study were obtained from the *Astromaterials Research and Exploration Science division* of JSC. The desorption experiments were carried out on a 5cc sample of aerogel used for fabricating the sample collector array on Stardust. This is henceforth referred to as "preflight" aerogel. Standard aliquots of a noble gas mixture were adsorbed on aerogel in an evacuated stainless steel finger by using an external liquid nitrogen bath (77K). The temperature was regulated from 77K to 240K by a specially designed heater. Gases liberated at control temperatures were measured by a MAP 215 noble gas mass spectrometer.

The stepwise heating experiments involved 2 samples collected from an aerogel tile, #44, from the mission, henceforth referred to as the "flown" aerogel. Sample preparation was carried out at Berkeley using standard procedures [4]. One of these was a chip (R2, weight = 0.04mg) taken from the "comet-facing" surface. Care was taken to avoid any tracks from colliding cometary particles. The other was a visually similar chip (C1, could not be weighed due to technical difficulties) taken from the bottom of the tile. The samples were packed in pre-degassed (at 1300 °C) Pt capsules and shipped to Mainz for mass spectrometry. Gas extraction was carried out in an Iridium (C1) or Tantalum crucible (R2) by resistance heating. Noble gas measurements were carried out on a MAP 215 noble gas mass spectrometer.

Prior to both experiments, the samples were baked overnight at 135 °C. The experiments were calibrated by procedural blanks and standard runs. A typical Pt foil blank (in ccSTP units) at 1700 °C was: $^{36}\text{Ar} = 1.5 \times 10^{-12}$, $^{84}\text{Kr} = 8 \times 10^{-14}$ and $^{132}\text{Xe} = 3 \times 10^{-14}$.

Results and Discussion:

Noble Gas Separation: The release patterns of Ar, Kr and Xe are shown in Fig. 1. Broadly, they are similar to the patterns observed in a much smaller sample (~ 0.3 cc) used as a pilot experiment (not shown in Fig. 1). While the precise effects of sample sizes, both of the gas and the aerogel, on the desorption curves remain to be investigated an example of noble gas separation, from the present data, is shown in Table 1.

Table 1. Noble Gas separation on aerogel.

Temp(K)	% release		
	^{36}Ar	^{84}Kr	^{132}Xe
102	99.3	4.7	1.0
132	0.4	93.2	3.9
190	0.1	1.8	94.1

The Ar/Kr/Xe separation on aerogel is better than a typical yield from charcoal in our setup.

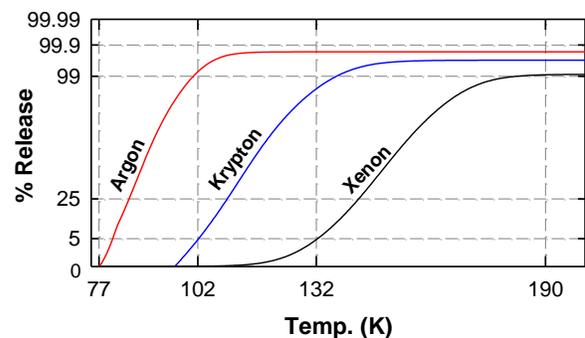


Fig. 1. Desorption of Ar, Kr and Xe from a 5cc sample of "preflight" aerogel. Experimental data were statistically analysed to obtain the best fit curves. The concentrations of these gases in the mixture used were: $^{36}\text{Ar} = 1.06 \times 10^{-8}$, $^{84}\text{Kr} = 7.4 \times 10^{-7}$ and $^{132}\text{Xe} = 2.13 \times 10^{-7}$ ccSTP.

Stardust heavy Noble gases: Based on typical flux calculations Mohapatra et al. [3] have suggested that the aerogel in the Stardust mission may have sampled noble gases (Ar, Kr and Xe) in the atmosphere of Wild 2 by very low energy implantation. For a density of 0.066 g/cm³ of the "preflight" aerogel they suggested that the implanted Ar, Kr and Xe would reside in the upper 4.5 to 32 nm region of the "comet facing" sur-

face. However, it is difficult to rule out any adsorbed gas on the aerogel either from the comet's atmosphere or acquired on Earth. In this context, a realistic "blank" would be provided by noble gas data from the surface that was away from the comet during the flight. This was the rationale of our sample selection protocol, i.e. the choice of C1 ("control") and R2 ("implanted surface").

Table 2 compiles the preliminary Ar, Kr and Xe data from the present study. In contrast to Ar and Kr, Xe measured in R2 is ~ 50 times that in C1.

Table 2. Ar, Kr and Xe concentrations (in 10^{-7} ccSTP/g units).

Sample	^{36}Ar	^{84}Kr	^{132}Xe
C1	2.77	0.33	0.14
R2	2.80	0.21	7.14

A remarkable observation in sample R2 is its high xenon content, the amounts of Ar and Kr measured being low as in C1 (Table 2). Clearly, considering the high surface area of aerogel one might expect it to have a significant adsorbed air component. Any such component would, however, be common to both C1 and R2, and thus be unable to explain the ~50 times enrichment in R2. It is also interesting to note that the concentration of xenon measured in R2 is higher than the highest reported data for xenon adsorption on terrestrial shales [5].

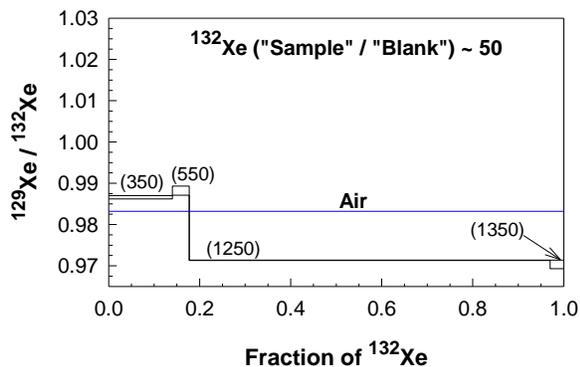


Fig. 2. Stepwise release of xenon from chip R2 from the "comet-facing" surface of aerogel tile 44 from Stardust mission.

The stepwise release pattern of xenon, in Fig. 2, shows that more than 80% of the sample xenon was released above 550 °C. As a comparison, the noble gas desorption data (Fig. 1) shows that xenon adsorbed on aerogel, as would be expected for adsorbed air, is released by 180K (-93 °C). Further, the isotopic signa-

tures of xenon released above 550 °C show a mass dependent fractionation trend favouring the heavier masses (Fig. 3), both relative to air and (generally lighter) extraterrestrial components. Such fractionation is expected in implantation of noble gases [e.g., 6].

Implantation of noble gases seems to be in line with the model predictions of [3]. But such model would suggest also the presence of significant amounts of Ar and Kr which are not observed in R2. In this context, further data from stepwise heating experiments on samples from other parts of the aerogel tile array will be critical.

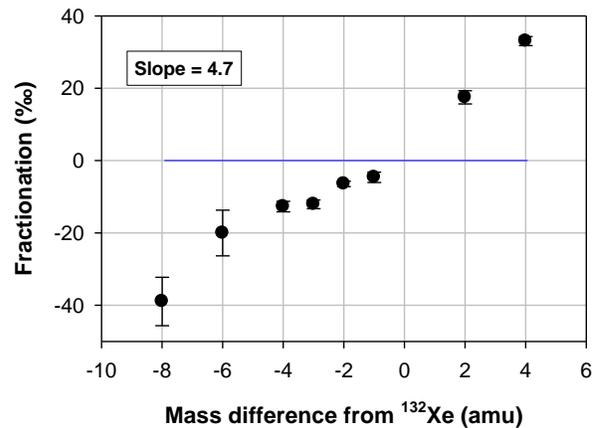


Fig. 3. Mass dependent fractionation in xenon observed in R2. Plotted is the deviation of the ^{132}Xe -normalized ratios from air in permill.

References:

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