

## PASSIVE HYPERVELOCITY NOBLE-GAS CAPTURE EXPERIMENTS

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INTRODUCTION Recent Comet Halley flyby data indicate that the volatile component of the coma is greater than 50% of the total mass as was assumed before the Halley missions [1]. This finding makes the capture and return of volatiles in a comet coma sample return mission even more important. As a first step in developing comet coma volatile collectors [2], experiments to assess the potential of capturing and analyzing coma volatiles by passive getters of noble gas have been performed. The results are reported here.

EXPERIMENTS As an initial effort in determining the potential for passive physisorption of comet volatiles, capturing heavy noble gas was selected as a worst-case assessment, for if heavy noble gas cannot be captured by passive physisorption, the more interesting organic volatiles such as H, N, CO, and CH<sub>4</sub> would not be possible either. A failure to capture, then, would indicate a need for more complex active chemisorption capture techniques.

The nominal comet coma sample return mission flyby speed was selected to be 10 km/s. At 10 km/s, the implantation energy even for noble gases is quite low, less than 100 eV; to ensure measurable results, very heavy xenon gas was selected for the experiment.

Acceleration of a neutral gas to 10 km/s would required the design of a new facility. Since at a low energies the effectiveness of passive implantation of noble gas ions would not differ from that of neutral gas atoms, a readily available ion accelerator was used [3]. Ultrahigh-purity xenon gas was used in a discharge to generate singly ionized xenon ions. To provide a bracket of implantation energy levels and provide a point of reference to known solar-wind experiment results, implantation energies of 50 eV, 100 eV, and 2.5 keV were used. A 15 minute implantation duration was selected to be the lower bound of expected collection duration of a comet coma flyby sample return mission.

The passive getter used in the experiment was a specially developed beryllium-copper alloy foil. The alloy consisted of 98% beryllium and 2% copper by weight. To enhance trapping probability for low-energy gases, a specially treated surface of beryllium-copper was also tested. As a control, a nonanodized aluminum foil used in the Apollo Solar Wind Collection experiment [4] was also included in the test. Care was taken to minimize any contamination.

RESULTS Prior to determination of the xenon abundance, implanted getters were exposed to a high vacuum at room temperature for several weeks. Due to the wide variation of the implantation levels in the getters, two mass spectrometers, both Reynolds type [5], were used. For higher levels of Xe<sup>+</sup> samples, direct-ion-collection mass spectrometer was used; for lower levels of Xe<sup>+</sup> samples, a mass spectrometer with an electron multiplier was used. Xe<sup>+</sup> abundances in the getters were determined by comparison of the <sup>132</sup>Xe signal with that in the air. Blanks were run between samples using the same procedure.

The efficiency of capturing the Xe<sup>+</sup> ion is the ratio of the measured level of Xe<sup>+</sup> compared to the implantation level. The test results are summarized in

the Table 1. Although the numerical value of the capture efficiency was not high at either 100 eV or 50 eV, the spectrometer detection sensitivity was about six orders of magnitude greater than the implantation dosage:  $10^{-14}$  cm<sup>3</sup> STP <sup>132</sup>Xe.

Table 1. Passive Hypervelocity Capture of Xenon

Passive Getter Material	Implantation Energy	Implantation Duration	Measured Capture Efficiency
Non-anodized aluminum	2.5 keV	4.5 sec	0.8
Untreated beryllium-copper	2.5 keV	5.4 sec	$1.4 \times 10^{-2}$
	100 eV	15 min	$1.1 \times 10^{-4}$
	50 eV	15 min	$2.6 \times 10^{-4}$
Treated beryllium-copper	2.5 keV	4.5 sec	0.8
	100 eV	15 min	$2.9 \times 10^{-3}$
	50 eV	15 min	$2.3 \times 10^{-3}$

**FINDINGS** The passive physisorption of xenon at about 10 km/s for a 15 minute duration proved to be successful for a routine mass spectrometer analysis technique. In fact, there was a concern that the implantation dosage was too high and a switch was made from the High Sensitive Noble Gas Pulse Counting Mass Spectrometer [6], which has a basic sensitivity of about a thousand atoms with a safe upper level of a billion retained atoms. The implantation dosage at 50 eV was about twenty times higher than the safe upper limit of the high sensitive mass spectrometer.

We expect that the passive physisorption technique will work well for such other noble gases as neon and krypton. Further development work will increase our understanding of fractionation due to implantation and allow us to assess the ability to capture organic volatiles.

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**REFERENCE**

- [1] Balsiger, H. et al. (1986) Nature, Vol. 321, p. 330-334.
- [2] Tsou, P. et al. (1986) 20th ESLAB Symposium.
- [3] Chutjian, A. (1984) Phys. Rev. A, Vol. 29, p. 64-69.
- [4] Geiss, J. et al. (1970) Journal of Geophysical Research, Vol. 75, No. 31, p. 5972-5979.
- [5] Reynolds, J. H. (1957) Rev. Sci. Instr., Vol. 27, p. 928-934.
- [6] Hohenberg, C. M. (1980) Rev. Sci. Instr., Vol. 51, p. 1075-1082.