Mercury’s exosphere shows a fascinating species-dependent variation in abundance and spatial distribution for Na, Mg, and Ca, identified by the Ultraviolet and Visible Spectrometer on the Messenger Surface, Space Environment, Geochemistry, and Ranging (MESSENGER) spacecraft, and for K from ground-based observations [1,2]. In particular, measurements of exospheric Na relative to K abundance vary hugely—from 22 to 400 depending on observation time and location with respect to Mercury’s surface [3,4]—and differ significantly from the average lunar Na/K ratio of ~6 [4]. The source of this discrepancy is a mystery, but potentially due to differences in regolith composition, production processes and rates, transport mechanisms, and/or loss processes.

In this laboratory simulation, we investigate the effect of regolith temperature on two of these physical parameters: (1) the thermal desorption of adsorbed potassium (K), as well as (2) the sputtering yield for adsorbed K on mineral surfaces by solar wind ions. Variation in sputtering yield as a function of temperature may be an important factor for exospheric production of volatile elements [5,6], which has not been previously investigated systematically. Temperature variation across the Hermean surface is significant—from look on Mercury’s darkside and within permanently shadowed regions to day-side within the north equatorial regions. Thus, measurement of the thermal dependence of ejection parameters is of high importance for understanding Mercury’s exosphere kinetics, as data from Messenger continues to be processed and with BepiColumbo data expected in the future.

**Experimental Details**

**PHI Versaprobe III Scanning XPS Microprobe**
1. ultra-high vacuum (~2 × 10⁻¹⁰ Torr)
2. In-situ preparation chamber (~3 × 10⁻¹⁰ Torr)
3. Hot-cold stage (110 K: 850 K)
4. XPS (spatial resolution < 10μm; sensitivity < 0.001%; FWHM < 0.6 eV)
5. Ion gun for He irradiation and depth profiling (E = 0.55 – 5 keV)
6. Low-energy ion and electron flood guns for charge compensation

X-ray photoelectron spectroscopy (XPS) provides quantitative compositional information within a surface layer of ~5 nm. XPS spectra were obtained using a spot size of 200 μm and a pass energy of 140 eV.

**Ion irradiation:** 4 keV He ions, which simulate the solar wind, were rastered uniformly over an area of 8 mm x 8 mm (much larger than the analysis area) at a flux of ~ 7 × 10¹⁰ He/cm² s. Samples were Zalar-rotated during irradiation, where the ion beam was 60° with respect to the surface normal.

**Substrates:** Sections of magnetite (Fe₃O₄) with ilmenite (FeTiO₃) inclusions, characterized by X-ray powder diffraction (XRD), were cut with a diamond saw, cleaned in an ultrasonic bath of methanol, purged with dry N₂ gas, and then admitted to the vacuum chamber. Prior to K-deposition samples were sputter cleaned with 4 keV He⁺ to remove atmospheric contamination.

**Conclusion**

- **The depletion cross sections by 4 keV He⁺ for potassium adsorbed on magnetite show a dependence on irradiation temperatures at 110 K – 400 K.**
- **The depletion cross sections by 4 keV He⁺ irradiation at ~300 K for potassium adsorbed on magnetite is similar to that for sodium adsorbed on olivine or CaO.**
- **Thermal desorption was observed for potassium adsorbed on magnetite at temperatures above 300 K.**
- **Irradiation of a substrate enhances the inward diffusion of the adsorbed potassium, rapidly distributing K deeper into the surface.**

**Relevant Publications:**

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