AN ULTRAVIOLET REFLECTANCE SURVEY OF SOME MATERIALS RELEVANT TO PLANETARY EXPLORATION. D. M. Applin¹, M. R. M. Izawa¹, and E. A. Cloutis¹

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Introduction: The 0.2-0.4 μm portion of the electromagnetic spectrum (here referred to as the UV) is largely underexploited in planetary remote sensing. This is due to generally very low albedo (and therefore low SNR), the strength of Fe-O charge transfers in materials common on many planetary bodies [1], electronic transitions of atmospheric gases, and a general lack of laboratory studies on the UV reflectance of solid-state materials.

Despite this, there may be applications for the exploitation of the UV spectrum in exploration, such as bodies that are atmosphere free, water ice-rich, organic rich, and highly reduced.

Here we show the UV reflectance of a number of planetary-relevant materials that have, to date, not been spectrally characterized in the UV.

Methods: Our experimental procedure for reflectance spectroscopy from 0.2 to 0.4 μm is discussed in detail in [1].

Solid state polycyclic aromatic hydrocarbons (PAHs): Solid state PAHs show a wide range of ultraviolet-visible absorption features and fluorescence features (Fig. 1). These features are attributed to various electronic mechanisms. The UV spectra of Pluto and Charon have recently been observed [2] and a hydrocarbon component was discussed as a plausible surface component.

Carboxylates: Carboxylates are expected to form where carbonaceous materials are exposed to highly oxidizing conditions [3]. Carboxylates have unique UV reflectance properties, (Fig. 2). The effect conjugation has on the n→π* absorption is apparent. Acetates show this feature at ~0.2 μm, whereas this feature occurs at ~0.25 μm in oxalates due to the enhanced conjugation.

Carbonaceous materials: Most are blue sloped at higher energies, while some highly aromatic materials show a broad peak near 0.24 μm (Fig. 3). We have observe a feature near 0.398 μm, which is attributed to the metalloporphyrin Soret absorption. This feature has previously been observed in meteorites [4].

Sulfides: Sulfides are suggested to be present on Mercury in significant abundance. [5]. The UV reflectance of these materials are quite variable (Fig. 4), with differences in slope and positions of features.

Hydroxides and cronstedtite: The absorption band at 0.26 μm in brucite is somewhat consistent with the few UV data points observed in Ceres reflectance [6]. Aluminum hydroxide appears quite similar, with features potentially shifted in wavelength. Goethite and cronstedtite are probably more consistent with the UV observations of Ceres, as reflectance rises strongly towards lower wavelengths.

HED meteorites: HEDs show some amount of spectral variation (Fig. 6). There is considerable structure in the absorption band near 0.25 μm, which appears to be a complex envelop of multiple metal-oxygen charge transfers. These are apparent in continuum-removed reflectance, which is not shown here. Though interesting, the subtleness of this complexity is not likely exploitable in remote sensing with current technologies. The UV reflectance of meteorites is also complicated by terrestrial weathering, which has a very strong effect in the UV.

Discussion and conclusions: Here, we show that there exists a wide variety of UV reflectance properties among materials relevant to planetary exploration.

High SNR data may provide compositional information based on subtleties in superimposed metal-oxygen charge transfers, but this is likely confined to the laboratory. Despite the perserviveness of the Fe-O charge transfers, when grain size can be somewhat constrained, the UV reflectance may be used in ways analogous to the 3 μm water absorption features for deriving surface composition.

UV reflectance may be particularly important for the Kuiper Belt Objects or other bodies that may be rich in water-ice. Water ice is flat and exceedingly bright through this UV region, and would provide much higher SNR. Of particular interest is the wide variation of features in solid state organics, be it small carboxylates, PAHs, or other highly condensed aromatic materials. All of these organic materials are likely highly abundant in many carbonaceous asteroids and comets, and UV spectroscopy may therefore be particularly useful in remote sensing of these bodies.

Acknowledgements: This study is supported by the Canadian Space Agency (CSA) through various programs, and NSERC. HOSERLab was established with funding from CSA, the Canada Foundation for Innovation, the Manitoba Research Innovations Fund, and the University of Winnipeg.

Figure 1. UV reflectance of various PAH compounds.

Figure 2. UV reflectance of acetate and oxalate carboxylates.

Figure 3. UV reflectance of various hydrocarbon materials.

Figure 4. UV reflectance of sulfide and opaque minerals.

Figure 5. UV reflectance of hydroxides and cronstedtite.

Figure 6. UV reflectance of HED meteorites.