

COMPOSITIONAL DEPENDENCIES IN ULTRAVIOLET REFLECTANCE SPECTRA OF SYNTHETIC GLASSES RELEVANT TO AIRLESS BODIES. A. S. Greenspon¹, C. A. Hibbitts¹, and M. D. Dyar². ¹Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20773, andy.greenspon@gmail.com; ²Dept. of Astronomy, Mount Holyoke College, 50 College Street, South Hadley, MA 01075.

Introduction: A goal of many missions to airless bodies is to determine the mineralogical and chemical composition of the surfaces in an attempt to understand the origins of these bodies and to gain insights into processes that affected their evolution to their current states. Reflectance spectroscopy is a proven method for gaining insight into both chemical and mineralogical properties. Commonly used at infrared wavelengths, spectroscopy can be plagued by the lack of strong spectral features on highly weathered surfaces containing glasses and agglutinates [e.g. 1]. The resultant bland spectra do not lend themselves easily to unraveling composition, and an alternative approach that is robust against space-weathering effects would be a valuable tool to planetary scientists.

Ultraviolet (UV) reflectance spectroscopy from the visible into the vacuum UV offers a potential means for uniquely identifying mineralogy and composition [e.g. 2]. In this paper, we present UV spectra from the vacuum UV into the visible (130 – 400 nm). We characterize the UV spectra of synthetic glasses and natural mineral samples relevant to airless bodies and relate identifiable spectral features to the chemical composition of each sample. Temperature dependence of spectra is also investigated.

Experimental Setup and Procedure: Samples were chosen based on their compositional similarities to regolith on the Moon, and possibly on Mercury and silicate asteroids. Glasses were selected because of the predominance of agglutinates and glass rinds in the lunar soil, as in [1]. Samples include synthetic low water content basaltic glasses (Table 1), volcanic sand containing olivine, and labradorite feldspar (nominally $\text{Na}_{0.4}\text{Ca}_{0.6}\text{Al}_{0.6}\text{Si}_{2.4}\text{O}_8$). We also present a spectrum for water ice as a test of our experimental setup.

Samples were hand ground to talc-like consistency ($<10 \mu\text{m}$). Approximately 100 mg was placed in a holder behind an MgF_2 window, with a thermocouple for accurate temperature measurements. The holder was placed in a chamber, which was then sealed and pumped down to 10^{-7} – 10^{-8} torr. The sample can be cooled to ~ 120 K using liquid nitrogen conductive cooling and heated to ~ 710 K through a combination of conductive and radiative heating. A manipulator integrated vertically into the chamber allows for rotating and elevating the sample to obtain spectra while under vacuum and heating/cooling. Powdered MgF_2 behind an MgF_2 window is used as a diffuse reflectance standard.

A deuterium lamp is used as the light source. An evacuated (10^{-4} torr) monochromator scans through the desired wavelength range (130 – 400 nm), and a photomultiplier tube with scintillation surface detects the reflected light. MgF_2 lenses in the chamber focus both the input and reflected illumination. A spectrum is obtained in two parts because the spectral range covers two orders. The 130 nm – 200 nm range is obtained without an order sorting filter, and the 200 nm – 400 nm range is covered with a filter to block light from the shorter wavelength order. An overlap of ~ 15 nm is included for each segment, and the spectra are scaled to match within the overlap region (Figures 1-3).

VUV Reflectance Correction: The MgF_2 used as a standard is UV grade and has a flat nearly 100% transmission from ~ 400 to 210 nm but begins to decrease in transmission at shorter wavelengths, reaching $\sim 60\%$ by 120 nm. This darkening of the standard results in an artificial brightening of the calculated reflectance (Figure 1). Therefore, a correction factor is required to remove this artifact. We employ an empirical correction using glass sample K-

2294, which has a nearly flat reflectance from 400 nm down to around 200 nm, at which point the uncorrected reflectance rises quickly to $\sim 17.5\%$. Due to strong electronic absorptions in this range, it is expected that the reflectance should remain dark and flat. Therefore, it is assumed that reflectance increasing shortward of 200 nm is due to a decrease in reflectance by MgF_2 , not increased reflectance by K-2294 (Figure 1). This correction factor was then

Table 1. Glass Compositions Studied (% by Mass)

Sample	K-2296	K-2295	K-2294	K-2292	K-2289	85-3	83-59
SiO_2	45.50	46.10	46.26	44.97	50.19	61.20	65.28
TiO_2	0.40	1.60	0.98	0.30		0.68	0.49
Al_2O_3	7.90	14.30	12.98	26.74	13.45	16.22	16.70
FeO	5.59	3.15	4.26	1.23	0.00	2.03	1.68
Fe_2O_3	15.20	11.71	16.78	3.89	0.00	2.65	1.87
MnO						0.09	0.06
MgO	17.20	12.50	6.47	6.86	14.17	4.18	2.55
CaO	8.60	10.40	12.73	15.64	22.19	6.56	5.23
Na_2O		0.80	0.29	0.23		4.06	4.66
K_2O		0.10	0.04	0.05		1.03	1.50
P_2O_5						0.23	0.12
H_2O	0.36	0.47	0.66	0.20	0.49	1.44	0.31
Total	100.75	101.13	101.45	100.11	100.49	100.37	100.45

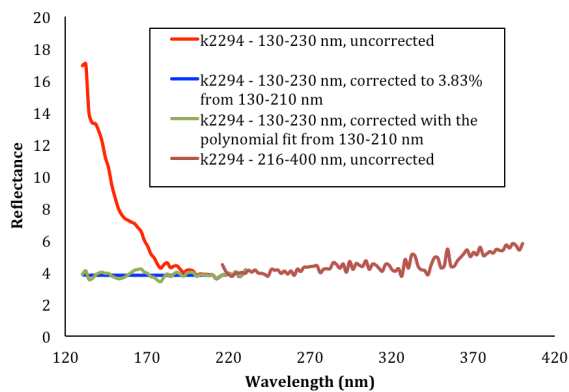


Figure 1. Uncorrected and corrected data for K-2294. Data taken from 216-400 nm require no correction factor.

plotted and fit to a polynomial of order 3. This polynomial was then used to perform the actual correction on all of the data taken below 210 nm (Figure 1-3).

Results: Reflectance data for 7 samples were obtained. Several were taken at temperatures from 296 K to ~ 530 K before and after heating to ~ 710 K. No significant differences were noticeable between spectra of different temperatures.

Water ice data was also collected by placing powdered MgF_2 in the sample holder, cooling the sample down to ~ 120 K, exposing to atmosphere so a thin frost would form, and then evacuating the chamber once more. Water frost accumulated over the surface of the MgF_2 window on the sample holder. The water ice spectrum in Figure 2 is as expected from others' works [e.g. 3], with ~ 100% reflectance above 180 nm, with a drop off around 170 nm to ~ 0% reflectance below 160 nm.

Figure 3 displays spectra for the synthetic glass samples. Iron content significantly affects the Vis-UV slope with higher iron content leading to a shallower slope and overall significantly decreased reflectance.

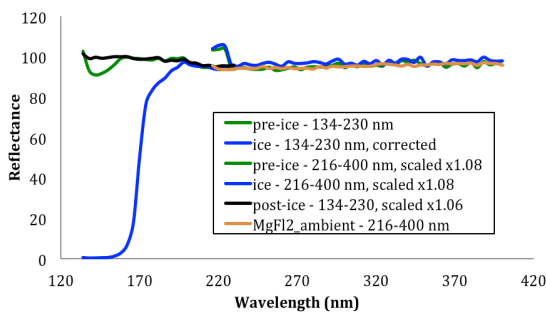


Figure 2. UV reflectance spectra of water ice on an MgF_2 window covering powdered MgF_2 . An MgF_2 reflectance spectrum under ambient atmospheric conditions from 216 – 400 nm is shown for comparison.

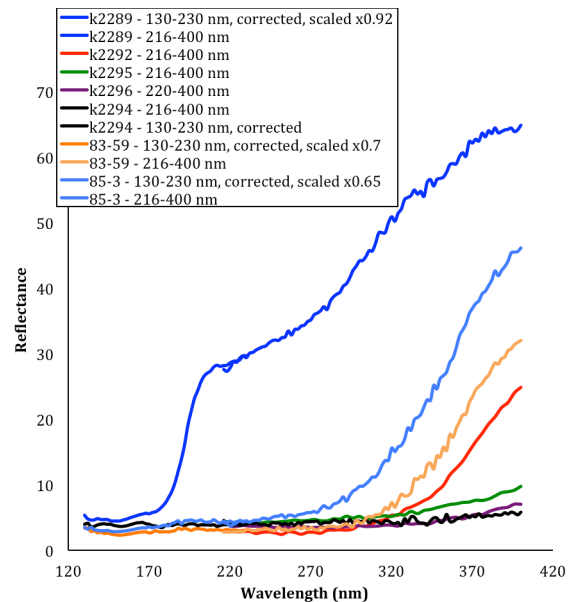


Figure 3. The UV reflectance spectra of synthetic glasses. Note that as Fe content increases, the overall reflectance begins to decrease significantly.

However, sample 85-3 has a larger slope and reflectance than 83-59 despite slightly higher levels of Fe. This could possibly result from the higher levels of internal water, magnesium, or calcium in 85-3 compared to 83-59, or possibly a shifted water absorption spectrum for adsorbed vs. crystalline water. Also, the larger slope and overall reflectance for samples 83-59 and 85-3 compared to k2292 might be a result of increased silica or lower aluminum/calcium content in the former two compared to the latter.

Below 220 nm, the spectra of all the samples appear flat except for K-2289, which has a significant drop off between 210 and 180 nm that could be used as a distinguishing factor for high silica, low iron or titanium content compositions. These spectra demonstrate that charge transfers in iron and titanium ions cause significant absorptions for samples between 200 and 300 nm.

Future work includes obtaining additional spectra of samples with varying iron, titanium, aluminum, and water content. We also expect to increase the range of our spectroscopy data further into the visible and compare this data to the MESSENGER MASC-VIRS spectrometer data.

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References: [1] Blewett, D.T. et al., (2011) *LPSC XLII*, 1044. [2] Cloutis, E.A. et al., (2008) *Icarus*, 197, 321-347. [3] Hendrix, A.R., Hansen, C.J., (2008) *Icarus*, 193, 323-333.