Electrostatically Charged Dust Grain Interactions with Phospholipid Bi-layers. M J. Schaible[1,*] and T. M. Orlando[1], [1]School of Chemistry and Biochemistry, Georgia Institute of Technology (*mjschaible@gatech.edu).

Introduction: The need to account for the dangers of radiation in human space exploration is well understood. Ionizing radiation poses a risk to astronauts involved in exploration activities both by direct radiation exposure, and indirectly through, e.g., electrostatically charged dust grains. Ionizing radiation damages organic molecules primarily through the creation of low energy electrons (LEE) and subsequent interaction with molecular resonance states. These interactions can lead to the breaking of molecular bonds, impairment of function, and adverse health effects.

Another well-known risk associated with human and robotic space exploration is the electrostatic charging of regolith dust grains and their potential adhere to surfaces. Toxic effects of dust are well known in Earth environments, and the energetic processing of regolith can create unsatisfied surface bonds, potentially enhancing the surface reactivity. Similar to LEE, electrostatically charged dust grains which come into contact with biologic material can exchange electrons, potentially damaging molecular bonds in the process. Therefore, it is important to have a means of discharging and passivating regolith grain surfaces for safe exploration of airless body surfaces.

The goal of this work is to characterize damage caused by irradiated and electrostatically charged dust grains brought into contact with molecular bi-layers of the phospholipid DPPC, the same molecule that makes up cell wall membranes within lung tissue. The results obtained in this study will help determine the potentially toxic effects caused in lung tissues when they come into contact with space weathered regolith dust grains.

Experimental Design: A novel high vacuum system was constructed at the Georgia Institute of Technology, shown in Figure 1, and is used to bring electrostatically charged dust grains into contact with cell wall analogs composed of DPPC bi-layers. The bi-layer films are deposited onto bare Si substrates using Langmuir-Blodgett deposition. Dust simulants from the SSERVI CLASS team are electrostatically charged either through agitation induced tribocharging or exposure to electrons from a hot filament source. Grains are then allowed to fall onto the DPPC films. Patterning of the substrates before film deposition allows for co-registered analyses, such that changes in the morphology and surface chemistry of the same particular region of a film can be analyzed using multiple techniques, before and after particle deposition.

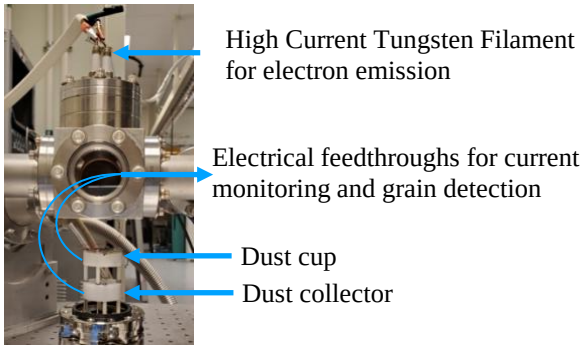

Figure 1: Experimental high-vacuum system for dust charging and grain exposure.

Film Characterization: Preliminary results show that DPPC films deposited onto bare silicon substrates can be readily identified using both atomic force microscopy (AFM) and x-ray photoelectron spectroscopy (XPS). These techniques are complementary in that AFM provides morphological characterization of the films while XPS provides a chemical description. Figure 2 shows a typical XPS spectra of the C-1s photoelectron region, and it can be seen that each of the distinct carbon bonding motifs can be distinguished.

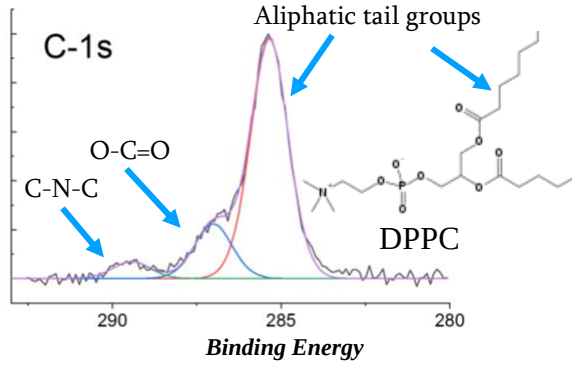

Figure 2: XPS spectra of the C-1s photoelectron transition of a DPPC bi-layer film deposited onto a bare Si substrate. A slightly cropped DPPC molecule is shown on the right.

Dust grain exposure: DPPC bi-layer films are positioned underneath the electrostatically charged grains, and agitation of the dust cup is used to mobilize the grains. As the dust grains fall, their surface charge is measured using a Faraday tube, and current is monitored on the conducting substrate. This work will present the first results of electrostatically charged dust grain effects on DPPC films, and discuss potential mechanisms for passivating dust grain surfaces.

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