

Potential Dangers and Mitigation of Electrostatically Charged Dust Grains on the Lunar Surface

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INTRODUCTION

The return of manned missions to the Moon requires characterization of and novel solutions to the unique problems posed by lunar dust. The unique environment of the lunar surface produces abundant electrostatically charged dust and space weathered dust grains that pose operational risks to both astronauts and hardware. Electrostatically charged grains can strongly adhere to surfaces such as astronaut suits, and subsequent tissue exposure in habitable environments can lead to adverse health effects. The dangers of fine dust exposure are well known in Earth environments, and the energetic processing of regolith on airless bodies can create additional toxic effects to processes occurring in the lunar environment. However, the unique risks posed by lunar dust are not well characterized, such as additional adverse effects caused by due to unsatisfied surface bonds or electrostatic discharge, largely due to the difficulty of studying grains in relevant environmental conditions. In addition to characterization, it is important to have a means of mitigating the risks of electrostatically charged dust grains for safe exploration of airless bodies. The goal of this work are two-fold: (1) characterize damage caused by irradiated and electrostatically charged dust grains brought into contact with biomolecules; and (2) test mitigation solutions.

EXPERIMENTAL DESIGN

A novel high vacuum system was constructed at the Georgia Institute of Technology. The system is able to electrostatically charge dust grains through several mechanisms, including: (1) tribocharging, (2), electron bombardment, and (3) UV photoemission charging. Lunar highland and mare dust simulants were obtained from the SSERVI CLASS team and are thoroughly dried at 100 C in a vacuum over for > 24hrs prior to the experiments. Grains can be mobilized by applying an electrostatic potential a grid located ~3mm above the dust surface, and individual grains can be passed through an aperture in the charging stage and allowed to fall onto the sample below. As the dust grains fall, their charge is measured using a Faraday tube, and the substrate is continuously monitored using a standard microscope camera.

RESULTS

Grain were placed on a variety of substrates to test the system ability to mobilize the dust grain. It was found that reduced graphene oxide polymer surfaces, in development by the SSERVI REVEALS team, were able to effectively repel tribocharged dust grains while applying only ~500V to the vibrating surface. Further, using patterned substrates and electrodynamic dust shield (EDS) technology combined with UV charging, grains were rapidly and efficiently removed from areas > 1"x1". Characterization of the rGO films before and after dust exposure show no appreciable changes in the film conductance or the chemical properties. It was found that the smallest size fraction of the dust <1µm, tends to become strongly adhered to the rGO surfaces, such that even sustained nitrogen flow cannot dislodge them. Photoelectric charging of dust particles via UV enhances the performance of the EDS system. These charged particles are more easily repelled by the travelling electric fields, reducing the voltage requirement for the system. Further work is ongoing to test the effects of charged dust grains on biomolecules films. Films are characterized before and after exposure using atomic force microscopy (AFM), x-ray photoelectron spectroscopy (XPS) and infrared spectroscopy (FTIR). Preliminary analysis of charged dust grains with the phospholipid films deposited on bare silica showed that the grains did not strongly adhere to the surfaces, but that discharge caused changes in the molecular bonding and film morphology.

This work was directly supported by the NASA Solar System Exploration Research Virtual Institute (SSERVI) under Cooperative Agreement NNA17BF68A (REVEALS) and a NASA NPP award to M.J. Schaible.