A NEW INVESTIGATION INTO RADIATION-INDUCED DIAGENESIS OF ORGANIC MATTER, WITH APPLICATIONS TOWARD EUROPA.

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Introduction: Europa's radiation budget is dominated by energetic electrons, protons, and ions that form the magnetospheric torus of Jupiter [1-6], which can induce biotic and abiotic diagenesis in organic matter that may be present at the surface. High energy electrons (keV to MeV range) penetrate the farthest, causing several thousand to a million chemical alterations for each incident particle and generating secondary radiation that can reach several cm to m below the surface. Altered surface material can be sputtered into space by further radiation, and the chemical transformations themselves can evolve gas signatures that could be detected by instruments at or above Europa's surface (e.g. the presence of O_2 in Europa's tenuous atmosphere).

With habitability as a major focus for the upcoming mission to Europa, we have recently initiated an effort to better understand Europa's intense radiation flux and how it alters subsurface and surface biosignatures and organic matter. While radiation alteration studies have been performed for a variety of organic species at room temperature, we focus here on the sputtered chemical byproducts and evolved gases from radiation of organic matter in ice in Europa-like environments.

Methods: The overarching goal is to catalog unique radiation-altered signatures that are sputtered or desorbed during radiation of selected classes of biologically-relevant species (i.e. hydrocarbon polymers, sugar polymers/carbohydrates, amino acid polymers/peptides, radiation-resistant spores, and radiation-resistant vegetative cells). We will embed representatives from each of these classes in ices of Europa-like compositions and then expose them to relevant radiation doses with energies that are high enough to penetrate several microns into the ice. Although low energies <5 keV do initiate some surface reactions [7], higher energies are needed to penetrate further through the ice matrix (NIST ESTAR models give stopping depths of approximately 30 μm for 10 keV and ~200 μm for 100 keV). To this end, we have installed a 100 keV electron source for use in these experiments.

For analysis of the ice, we have combined an in-situ cryogenic mass spectrometry technique previously developed in our laboratory (2-Step Laser Ablation and Ionization Mass Spectrometry (2S-LAI-MS) [8-10]) with a quadrupole mass spectrometer to track the radiation-sputtered or evolved gases in real time. This project will yield empirical data relating unique signatures from evolved gases and sputtered radiated organic materials with their pristine (original) counterparts. This work could provide key guidelines for organic matter detection instrumentation and for interpretation of data.

Goals of this Work: We will test gas and sputtering evolution under several different radiation doses to determine the relationship between dose and production rate to estimate whether these gases might be observable on Europa. This work will begin to unravel the relationship between major classes of pristine organic surface material and their associated gases and sputtered radiation products ejected into the atmosphere. This effort may help NASA to narrow parameters for detection of possible organic signatures at Europa and on other icy bodies exposed to radiation. Further, by establishing a link between the altered surface material composition and the outgassed species emanating from radiation-affected surfaces, this work will aid in mission planning and give new insight into future data returns from mass spectrometric flyby instruments like SUDA and MASPEX.

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