National Aeronautics and Space Administration

# Organic Chemical Transformations on the Surfaces of Ceres and Enceladus

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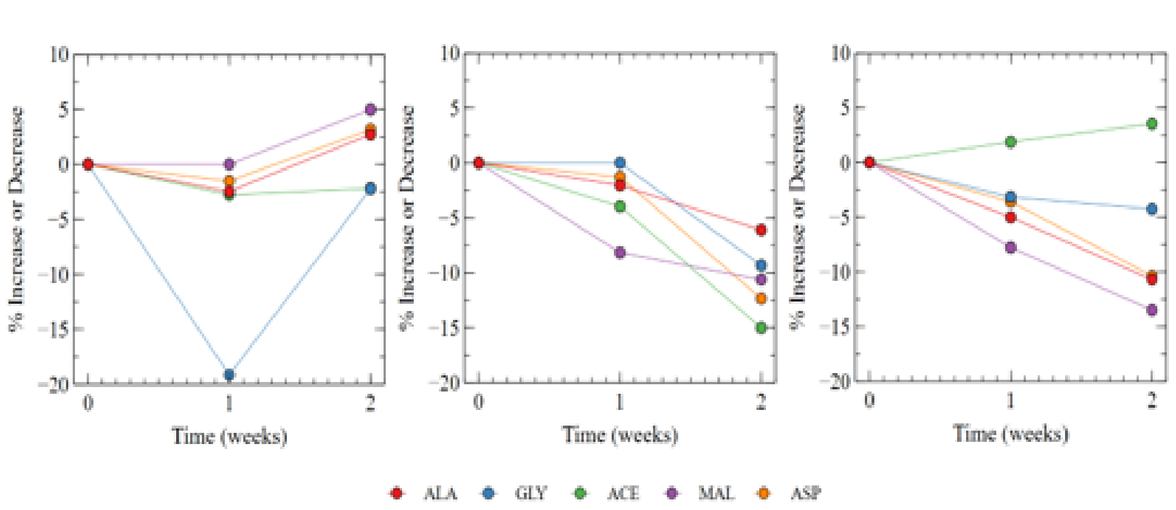
Program: FY22 R&TD Strategic Initiative
Strategic Focus Area: Fate of Organics in Ocean Worlds - Strategic Initiative Leader: Bryana L Henderson

## Objectives

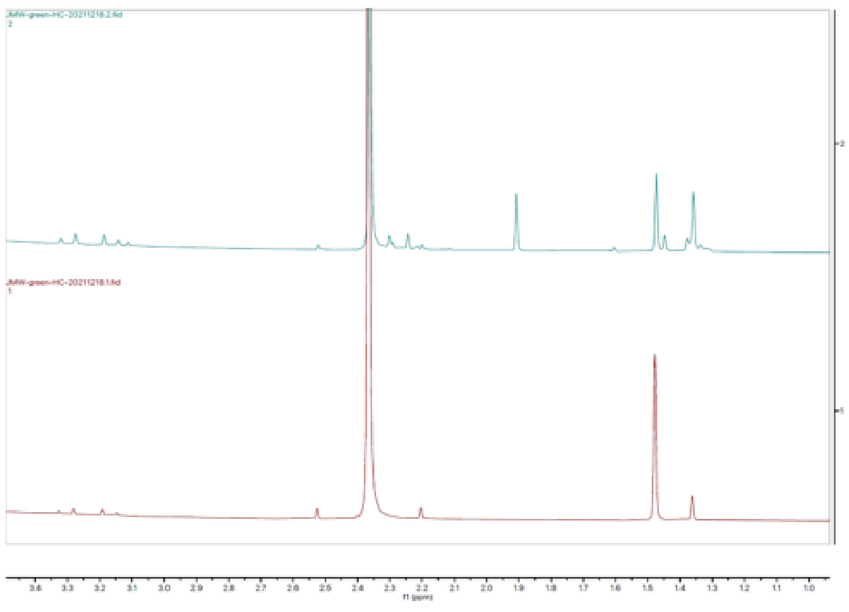
Our overall objective is to experimentally determine the fate of organic molecules on the surface of Ceres, by examining the photocatalytic degradation of selected organics on iron minerals. Specifically, in past year our objective has been to measure the adsorption capacity of Ceres-type minerals for a set of relevant organics, such as amino acid and small carboxylic acids.
Additionally, we have examined the phtotchemical activity of a set of small organic acids, both pure and adsorbed onto the surface of iron minerals. Both iron hydroxide and iron sulfide minerals were studied.
To our knowledge, these studies have not been previously performed under the conditions representative of planetary environments. The data we generated is unique and will enable a new understanding of organic

chemical transformations on the surfaces of ocean worlds.

## Approach and Results



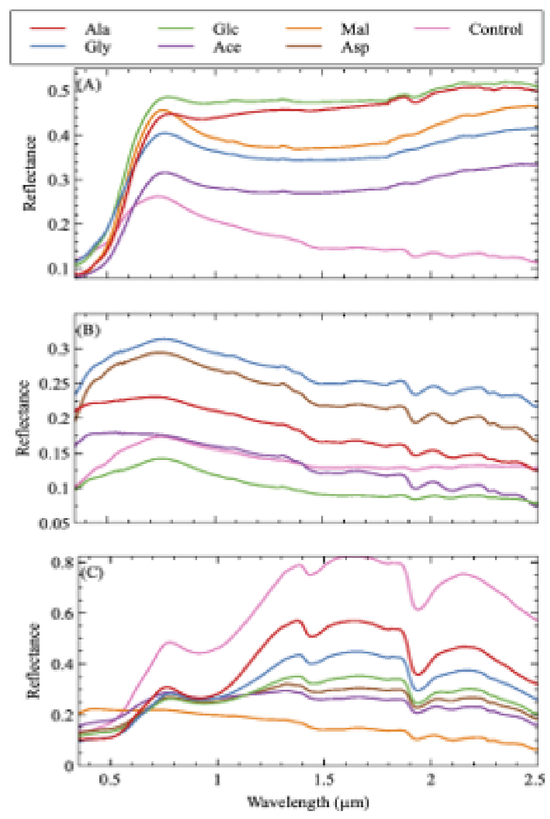

Iron sulfide minerals of various starting oxidation state were exposed to aqueous organic solutions for up to two weeks, and the concentration of organic in the supernatant measured by NMR.



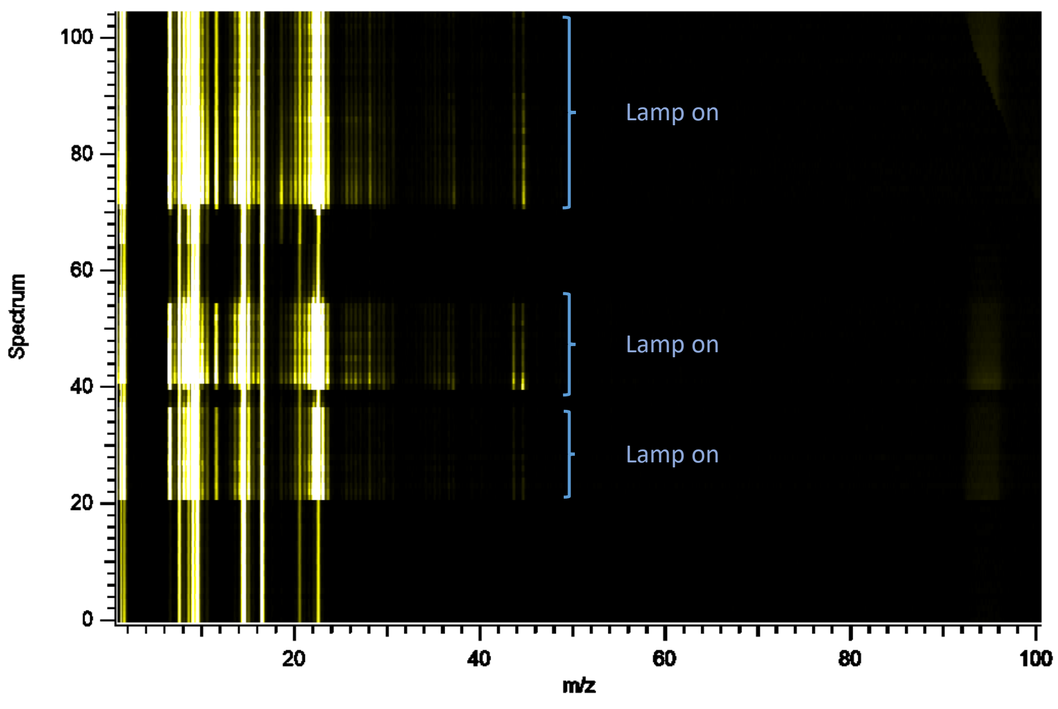
NMR spectra of pyruvate before (bottom) and after (top) 24 hours of broadband irradiation with 400 W Xe arc lamp. Note peaks corresponding to new products in the upper trace.

## Significance/Benefits to JPL and NASA

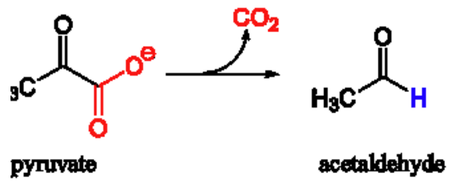
This proposed task is closely linked to the other two tasks in this initiative: “Carbon Cycle in Small Ocean Worlds”, led by PI Castillo-Rogez, and “Understanding abiotic organic chemistry driven by minerals in Ceres’ and Enceladus’ oceans”, led by PI Barge. This initiative is the first to address the fate of organics in Ocean Worlds and is in direct response to SSED priorities. It will identify robust biomarkers, false positives to be avoided, and effective detection strategies (instrumentation, target locale, species) for in-situ (bio)signature analysis on Ocean Worlds. Our initiative will augment future opportunities for mission infusion for Ocean Worlds (e.g., Europa Clipper, Ceres, in situ / sample return). At the end of this work, we will identify high-fidelity biomarkers and conditions under which they may be preserved to identify science technologies for future investment. It will also enable new mission formulation for other high-priority Ocean Worlds, such as Neptune’s moon Triton and Uranus’ moon Ariel.




Near infrared reflectance spectra of iron (oxy)hydroxide/organic assemblages. These spectra will be compard to Dawn spectra of Ceres.




Mass spectra showing direct desorption and decarboxylation (below) of pyruvic acid during Xe lamp irradiation

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## Publications:

Martinez E., Flores E., Valadez D., Weber J.M., VanderVelde D., Sheppard R.Y., Hodyss R.P., Castillo-Rogez J., Henderson B., Barge L.M. Organic Adsorption onto Iron Sulfide and Hydroxide Minerals: Implications for Ceres Sample Analysis. JGR Planets (In prep for submission September 2022).

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