ADVANCING THE CURATION OF ALDEHYDES AND KETONES FOR APPLICATIONS TO CARBONACEOUS CHONDRITE CURATION AND COMETARY NUCLEUS SAMPLE RETURN

P. J. A. Hill[1], M. Chevalier[1], C. D. K. Herd[1], and R. W. Hilts[2], [1]Department of Earth and Atmospheric Sciences, 1-26 Earth Sciences Building, University of Alberta, Edmonton, AB, Canada pjhill@ualberta.ca, [2]Department of Physical Sciences, MacEwan University, Edmonton, Alberta T5J 4S2, Canada.

Introduction: The presence of abiogenic organic compounds in carbonaceous chondrites and cometary material marks an important starting point for investigations examining the processes that led to the origin of life. Of particular interest are the aldehydes and ketones, commonly known as "carbonyl compounds", which play an important role in the synthesis of a range of organic compounds, including amino acids [1–3]. With ongoing sample return missions from asteroids, proposed future sample return missions from cometary nuclei, and the continual arrival of carbonaceous chondrites to the Earth's surface via meteorites, establish the ideal curation conditions for the preservation of extraterrestrial organic compounds that proactively prevent terrestrial reactions is essential for ongoing research. Given the importance of carbonyl compounds in the production of other organic compounds required for early biogenic processes, the aim of this study is to examine the reactivity of carbonyl compounds under a variety of conditions to provide insight into the curation and handling requirements of organic-rich astromaterials.

Methodology: To monitor the reactivity of carbonyl compounds under various curation conditions, a powdered mixture of the Allende meteorite was prepared as the medium for this study. A stock solution of (acetone, 2-butanone, 2-pentanone, and benzophenone) and 4 aldehydes (formaldehyde, acetaldehyde, propionaldehyde, and benzaldehyde), all known to be found in meteoritic and cometary materials, was added to the powdered mixture. 0.2 mL of stock solution will be added so that each 1 g sample of Allende will have an additional 10 ppm of each carbonyl compound of interest. This is in excess of the intrinsic concentration of carbonyl compounds within Allende as previous studies have indicated the concentration of total aldehydes and ketones within Allende to be 284 nmol g^{-1} (formaldehyde is the most abundant at 221.7 nmol g^{-1} or 6.6 ppm) [4].

Two procedural blanks are utilized in this study to act as controls and for points of reference. The first blank is pure, crushed silica which will undergo all the same experimental conditions as the Allende-carbonyl mixture. This will provide an understanding of the role the meteoritic material is playing versus just the reactivity of carbonyl compounds with each other within an inert medium. The crushed silica will be heated at 500℃ for 24 hours prior to use to remove any organic contaminants. The second blank is powdered Allende meteorite, with no extra carbonyl compounds added. This blank will be exposed to all the same experimental conditions, in order to ascertain background levels of carbonyl compounds and their reactivity. All three samples, the Allende-carbonyl mixture, silica blank and Allende blank, will be stored under various curation conditions to investigate reactivity of the compounds.

Three environments (a class 1000 cleanroom at 25℃; a class 1000 cleanroom at -15℃; and a -15℃-Ar atmosphere glove box) will assess how the carbonyl compounds react over a period of time at different temperatures and under different atmospheric conditions. To test what affects the availability of water has on any reactions, a fixed volume of water will be added to a subset of samples. Similarly, double-distilled ammonia will be added to each sample to see how ammonia interacts and affects the preservation of the carbonyl compounds. In this way, five main variables are assessed through this study: meteoritic material as a reactive medium; temperature effects; argon atmosphere vs. ambient air; the presence of water; and the presence of ammonia.

The extraction of the carbonyl compounds will follow the procedure described by Simkus et al. [3], which showed a high extraction efficiency as compared to other studies [4]. Implementing this procedure uses a hot water extraction method using ultrapure water followed by derivatization using O-(2,3,4,5,6-pentafluorobenzyl) hydroxylamine hydrochloride and separated using dichloromethane. The extractions will then be reduced to 200 µL under a stream of nitrogen before being analyzed by gas chromatography coupled to mass spectrometry.

Anticipated Results: Given the known reduction of reaction rates and preservation of indigenous volatile organic compounds associated with cold curation [5], it is anticipated that any reactions involving the carbonyl compounds will be reduced in colder temperatures. This should hold true for the reactions involving water as the water should solidify, greatly reducing any potential reactions. It is also anticipated that the argon atmosphere will reduce any oxidation reactions that would otherwise take place in ambient atmospheric conditions. It is also expected that the powdered Allende meteorite, as compared to the inert quartz, will retain the carbonyl compounds better due to stronger chemisorption onto the surface of the various silicate phases present [6]. This comparison will serve to demonstrate the reactive potential of any returned fine-grained material from asteroidal or cometary sample return missions.

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