A COORDINATED METHOD FOR ANALYSIS OF SOLUBLE ORGANICS IN EXTRATERRESTRIAL MATERIALS. J. E. Elsila[1,*], H. L. McLain[1,2,3], J. C. Aponte[1], D. P. Glavin[1], H. V. Graham[1], A. Mojarro[1,4], E. P. Parker[1], D. N. Simkus[1,2,3], and J. P. Dworkin[1]. [1]NASA Goddard Space Flight Center, Greenbelt, MD 20771, [2]Center for Research and Exploration in Space Science and Technology, NASA/GSFC, Greenbelt, MD 20771.[3]Department of Physics, Catholic University of America, Washington, D.C. 20064, [4]NASA Postdoctoral Program, Oak Ridge Associated Universities, Oak Ridge, TN, 37831, [5]Center for Space Sciences and Technology, University of Maryland Baltimore County, Baltimore, MD 21250.

Introduction: Analysis of the soluble organic content of extraterrestrial materials has been an area of interest for decades [see 1 for a review], with studies of meteorites [1]), interplanetary dust particles [2], lunar samples [3, 4], and cometary material returned by NASA's Stardust mission [5, 6] exploring the chemical history of parent bodies within the solar system. The more recent OSIRIS-REx and Hayabusa2 returns of carbonaceous asteroidal materials [7, 8] have led to increased efforts to maximize the information produced from analyses through coordinated efforts by scientists around the world.

We have previously reported on the advantages of a coordinated approach to soluble organic analyses compared to a more traditional targeted approach [9]. In the targeted approach, separate portions of a sample such as a meteorite are allocated for analysis of different organic compound classes, with sample preparation methods optimized for each specific analysis. In the coordinated approach, one homogenized sample is taken through a preparation flowchart, with aliquots removed at different points for the analysis of individual compound classes. The coordinated approach maximizes sample use efficiency, which is essential when working with small amounts of precious materials. It also allows a better comparison between compound classes, reducing differences caused by sample heterogeneity.

Here, we present an updated sample preparation flowchart, expanding our previous coordinated analytical methods to include additional compound classes. Both our previous and updated coordinated methods have been used for analysis of Apollo 17 samples through the Apollo Next Generation Sample Analysis (ANGSA) program [10], samples from asteroid Bennu [11], and Murchison meteorite samples [11], among others.

Analytical Methods and Results: Our previously reported coordinated approach enabled analyses of six compound classes: amino acids, amines, carboxylic acids, carbonyls (e.g., aldehydes and ketones), cyanides, and hydroxy acids (see Figure 1), with an initial step of extraction for 24 hours in water at 100 °C ("hot-water extraction"). We have explored two additional types of extraction: 1) sonication in water; and 2) additional extraction of the residue remaining after hot-water extraction in 6 N HCl at 105 °C ("acid extraction").

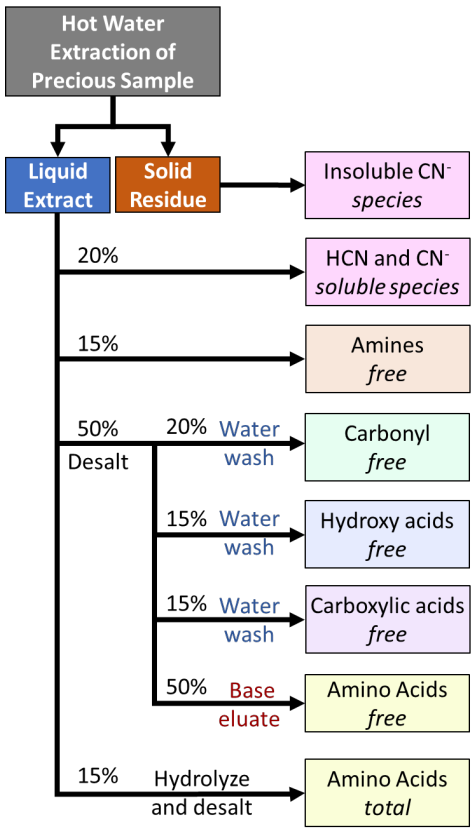

Figure 1. Our previously published [9] coordinated analysis targeted six different compound classes in various forms.

We varied both time and temperature variables to optimize the sonication extraction method. Times between 30 minutes and 2 hours produced similar results, leading us to establish a middle ground of 1 hour sonication time as our standard method. Temperatures of 30 °C and 60 °C were tested, with varying extraction efficiencies observed. The acid extraction method was developed separately for the analysis of hydroxy amino acids [12, 13].

These additional extraction methods allow our coordinated analysis to include three additional types of

compounds: fragile protein amino acids (e.g., asparagine (Asn), glutamine (Gln), and tryptophan (Trp)), peptides, and hydroxy amino acids. Fragile protein amino acids require more gentle extraction techniques, as hot water extraction degrades Asn and Gln into aspartic acid (Asp) and an unknown compound, respectively; Trp is also unstable under hot water extraction conditions. Peptides are also prone to hydrolysis under hot water extraction. We used homopeptides up to 6 amino acid residues in length to optimize our methods; additional optimization will be required for larger peptides [14]. Our updated coordinated plan is shown in Figure 2.

Conclusions and Future Work: The optimization of a coordinated method for the analysis of soluble organic compounds in precious astromaterials remains a valuable and ongoing activity. Although our current method is an improvement on our prior one, there is room for additional expansion. Future work may include the extraction and analysis of nucleobases and nucleosides [15] and other compound classes.

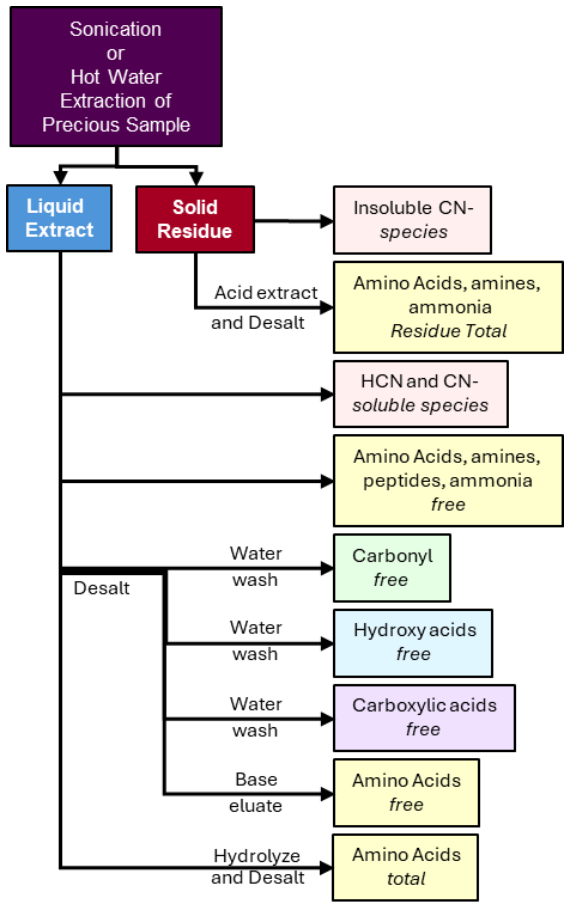

Figure 2. Our updated approach includes the option of sonication and acid extraction to enable analysis of additional compound classes.

References:

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