ANALYSIS OF CHIRAL CARBOXYLIC ACIDS IN METEORITES. A. S. Burton[1] , J. E. Elsila[2], J. E. Hein[3], J. C. Aponte[4], E. T. Parker[5], D. P. Glavin[2], and J. P. Dworkin[2]. [1]Astromaterials Research and Exploration Science Division (XI3), NASA Johnson Space Center, Houston, TX 77058; aaron.s.burton@nasa.gov, [2]Solar System Exploration Divison, NASA Goddard Space Flight Center, Greenbelt, MD 20771, [3]Department of Chemistry, University of California-Merced, Merced, CA 95343. [4]Catholic University of America, Washington, D.C. 20064. 5School of Chemistry and Biochemistry, Georgia Institute of Technology, Atlanta, GA 30332.

Introduction: Homochirality of amino acids in proteins and sugars in DNA and RNA is a critical feature of life on Earth. In the absence of a chiral driving force, however, reactions leading to the synthesis of amino acids and sugars result in racemic mixtures. It is currently unknown whether homochirality was necessary for the origins of life or if it was a product of early life. The observation of enantiomeric excesses of certain amino acids of extraterrestrial origins in meteorites provides evidence to support the hypothesis that there was a mechanism for the preferential synthesis or destruction of a particular amino acid enantiomer [e.g., 1-3]. The cause of the observed chiral excesses is unclear, although at least in the case of the amino acid isovaline, the degree of aqueous alteration that occurred on the meteorite parent body is correlated to the isovaline L-enantiomeric excess [3, 4]. This suggests that chiral symmetry is broken and/or amplified within the meteorite parent bodies.

Besides amino acids, there have been only a few reports of other meteoritic compounds found in enantiomeric excess: sugars and sugar acids [5, 6] and the hydroxy acid lactic acid [7]. Determining whether or not additional types of molecules in meteorites are also present in enantiomeric excesses of extraterrestrial information will provide insights into mechanisms for breaking chiral symmetry. Though the previous measurements (e.g., enantiomeric composition of lactic acid [7], and chiral carboxylic acids [8]) were made by gas chromatography-mass spectrometry, the potential for increased sensitivity of liquid chromatography-mass spectrometry (LC-MS) analyses is important because for many meteorite samples, only small sample masses are available for study. Furthermore, at least in the case of amino acids, many of the largest amino acid enantiomeric excesses were observed in samples that contained lower abundances (tens of ppb) of a given amino acid enantiomer. In the present work, we describe our efforts to develop highly sensitive LC-MS methods for the analysis of chiral carboxylic acids including hydroxy acids.

Analytical Methods: Carboxylic acid and hydroxy acid standards were purchased from Sigma Aldrich, Acros Organics, TCI America, or custom-synthesized. Resolution of enantiomers was achieved by derivatizing carboxylic and hydroxy acids with chiral derivatization reagents to form diastereomers that could be seprated using achiral stationary phases.

Results and Discussion: We have developed reasonable methods for the separation of broad suites of carboxylic acid and hydroxy acid isomers, and are in the process of optimizing extraction procedures to permit the analysis of chiral hydroxy and carboxylic acids in a range of carbonaceous chondrite meteorites.

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