DETECTING CHIRAL BIOSIGNATURES ON EUROPA WITH THE C-LIFE POLARIZED MICROSCOPE. D. Viola[1], S. Byrne[1], C. Drouet d'Aubigny[1], B. Williams[2], & B. Rizk[1], [1]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721, [2]Steward Observatory, University of Arizona, Tucson, AZ 85721.

Background: All life on Earth uses L-amino acids and D-sugars for metabolic processes. This enantiomeric preference, required for polymerization, protein folding, DNA replication, and metabolic activities, is thought to be a universal biosignature for organic life. Most of the physical properties of L- and D- enantiomers, such as molecular mass and boiling points, are identical. However, enantiomers rotate polarized light in equal but opposite directions. Therefore, in order to identify an enantiomeric preference within an environmental sample – and thus the possible influence of biological activity – polarimetry and polarization microscopy can be used to detect optical rotation. This method has been proposed as a life detection method for Mars and other astrobiologically-relevant worlds [1-3].

Europa, with abundant liquid water beneath its icy surface, is a prime astrobiology target. Since it is thought that the surface and the ocean have interacted in the past, it is plausible that chiral molecules from the ocean may be found on or near the surface of the moon today. NASA recently released a study delineating anticipated requirements for a future lander mission to Europa, which includes determining the presence of organic molecules and characterizing the associated enantiomeric excess [4].

Cold Lightweight Imagers for Europa (C-LIFE) is a landed camera suite consisting of a color stereo surface imager and color polarimetric microscopic imager. Here, we test our polarimetric microscopic imager to establish the concentration detection limit of chiral organic molecules and the effects of different complicating factors on this observational method.

Experimental Setup: The instrument design is similar to a saccharimeter. An LED light source is directed through a collimator and a polarizer with a narrow bandpass filter to produce plane-polarized light. The light then passes through a cuvette, meant to hold liquid samples, and data is collected by a camera with a polarized filter. The instrument set-up is shown in Figure 1. We have also obtained a cryomechanical cooler (Figure 2) to test experimental components at Europa-like temperatures (down to 26 K).

Experiment Plan: We plan to test the detection limits of this polarimetric imaging technique through a series of experiments. The theoretical detection limit, intrinsically linked to the instrument sensitivity and minimum rotation angle that we can confidently observe, will vary depending on the organic species present. We thus chose to start by analyzing two organic molecules: phenylananine, with a high specific optical rotation, and serine, with a lower specific optical rotation [summarized in Table 1]. In each case, solid reagent-grade (>98% pure) L- and/or D- amino acids will be dissolved in distilled water to produce stock solutions of known concentrations. Samples will be placed in the cuvette, and the rotation of plane polarized light through the sample will be obtained. Stock solutions will then be diluted to lower concentrations until no optical rotation can be detected.

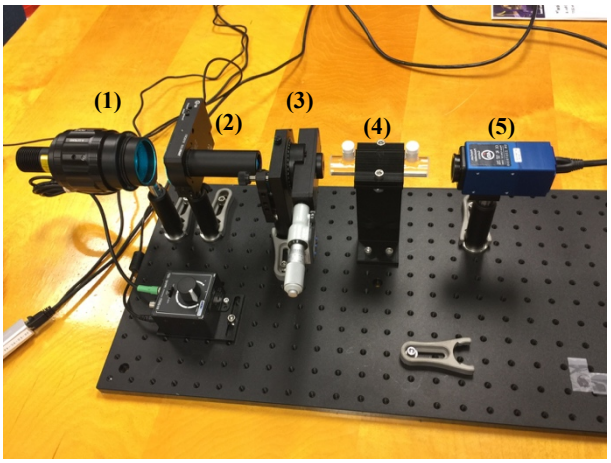
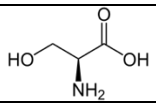
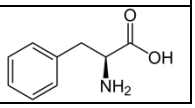


Figure 1. Experimental set-up. Components are (1) LED light source; (2) collimator optics and polarizer; (3) Soleil-Babinet compensator (for calibration); (4) cylindrical sample cuvette; (5) polarization imager camera.

Figure 2. Vacuum chamber with cold plate (left) with controlling electronics (right).

Table 1. Selected properties of amino acids to be used during the first phase of this study.

	Serine	Phenylalanine
Molecular formula	$C_3H_7NO_3$	$C_9H_{11}NO_2$
Molecular weight	105.09 g/mol	165.2 g/mol
Specific optical rotation	$[\alpha]_D^{20} - 6.83$	$[\alpha]_D^{18} + 70$
Water solubility	250 g/L (20°C)	16.5 g/L (20°C)
Chemical structure		

Serial dilutions. We will first confirm the lowest detectable concentration in dilutions containing single L-amino acids. Starting at high concentrations (2 M for serine and 0.18 M for phenylalanine), we will dilute samples to lower concentrations until reaching the detection limit.

Enantiomeric excess series. Abiotically-produced organic molecules are expected to form with roughly equal amounts of L- and D- molecules. Chiral molecules have been detected in molecular clouds [5] and in primitive meteorites [e.g. 6], where enantiomeric excesses as high as 60% have been observed for some amino acids [7]. A purely racemic mixture, with identical amounts of L- and D- amino acids, should have no optical rotation since the enantiomers will cancel each other out. With increasing enantiomeric excess (of either L- or D-molecules), we expect that the concentration of organic molecules required for the detection of optical rotation will decrease. To demonstrate this, we will prepare solutions of L- and D- amino acids with known enantiomeric excesses and measure their optical rotations at decreasing concentrations.

Mixed organic molecules. Next, we will measure the optical rotation of mixed organic molecules with different enantiomeric excess ratios. It is likely that any non-racemic mixture of organic molecules will have some degree of optical rotation, although the lower the enantiomeric excess, the higher the concentration required for detection via polarimetry.

More complex samples. Finally, we will build up to samples that will better simulate those expected for a Europa lander. This includes adding particulate materials to observe the effects of dust grains on our observing technique; measuring the optical rotation of a sample containing living and/or dead bacterial and unicellular eukaryotic cells; and collecting and analyzing terrestrial analog samples, without prior compositional knowledge. Living cells have been shown to exhibit optical rotation [8], so we hope to demonstrate the ability to detect the presence of cellular material in solution. In the case of unknown analog samples, it is plausible to use additional analysis techniques, such as GC-MS, to determine the molecular composition, place constraints on the enantiomeric excesses of individual components present in the sample, and demonstrate the interplay between different instruments that may be present on a future Europa lander. Furthermore, our investigation will examine the effects of freezing samples, as little research has been done to investigate water ice using polarimetry. These tasks will help to better understand the results that may be obtained from surface sampling on Europa.

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