INTERACTION OF LABORATORY THOLIN WITH LIQUIDS PRESENT IN, AND ON, THE MOONS OF THE OUTER SOLAR SYSTEM. B. N. Khare[1,2], C. P. McKay[1], C. Burkhard[1], S. Jagota[1], S. McPherson[1], D. Nna-Mvondo[3]. [1]Space Science Division, NASA Ames Research Center, Moffett Field, CA, USA, Bishun.N.Khare@nasa.gov, Chris.McKay@nasa.gov, cdburkhard@yahoo.com, Seeja2003@gmail.com, Scottamcp@gmail.com, [2]SETI Institute, NASA Ames Research Center, Moffett Field, CA, USA, [3]Centro de Astrobiologica (CSIC-INTA), Ctra. de Ajalvir, km 4, Torrejon de Ardoz, Madrid, Spain, nnamvondod@inta.es.

Introduction: The reason Europa, Titan, and Enceladus are the focus for future outer solar system missions is the combined presence of organic material and liquids; liquids that could offer a medium for the continued development of organic synthesis and potential prebiotic processes.

Our understanding of the organic processes that might occur in these distant liquids is preliminary and inadequate for the design of instruments for these impending missions. Initial studies have been conducted by Khare et al. (1986) who reported the production of amino acids in Titan tholin treated with 6N HCl. Nguyen et al. (2008) also conducted acid hydrolysis experiments of Titan tholins and found a wide diversity of O containing species produced from carboxylic acids to amino acids. Somogyi et al (2005) and Neish et al. (2008, 2009) conducted further experiments with Titan tholin in water and water/ammonia mixtures and found oxygen incorporation into the organic molecules. Experimental results show that oxygen incorporation was faster in the presence of ammonia [Neish et al. (2009)]. In contrast studies of tholin in liquid ethane (McKay 1996) have indicated a negligible solubility for complex organics, however solubility in analogous hydrocarbons at room temperature (e.g. hexane) was quite high – as high as water (McKay 1996). It may be that the timescale for solubility is longer at low temperatures while the total solubility remains high, but this has not been adequately investigated.

These studies have shown that an interesting organic chemistry probably results when tholin interacts with these liquids, however the information base that could be the foundation for an instrument design on a future mission remains undeveloped. We propose to develop the scientific strategy for near term analysis of the organic products of organic-liquid interactions on Europa, Titan, and Enceladus

Experiments: We have hydrolyzed Titan tholin in 6N HCl at 100°C for 20 hours. After standard cleanup procedure on an ion exchange column, the amino acids were derivatized to their TFA-isopropyl esters and chromatographs were obtained on both a Chirasil-Val, 30 meter x 0.2 mm id capillary column and a SP-2100, 50 meter x 0.2 mm id capillary column. Gas chromatography of the hydrolysates on the Chirasil-Val column demonstrates the racemic synthesis of amino acids. The richness of products implied by the infrared and amino acid analyses suggests that at least many of the GC/MS pyrolyzates are intrinsic to the tholin.

Our other previous work dealt with another tholin named Jupiter Tholin (spark tholin) that is synthesized as specified in Khare et al., *Icarus* 48, 290-297 (1981) which, upon interaction with ammonium hydroxide (pH 13) yielded substantial number of protein and non-protein amino acids that are relevant to astrobiology. We also found some indications of the presence of peptide bonds or of polyamidine structures.

The two lines in each of the chromatograms below represent the two wavelengths 570 nm (higher curve) and 440 nm (lower curve) of light used in measuring the transmission through amino acids after reaction with ninhydrin, eluted from the column of the Technicon TSM Amino Acid Analyzer using standard separations for physiological samples. The upper chromatogram is a blank using an empty cartridge. The middle graph is the control chromatogram, columns loaded with 50 nmol of norleucine. The lower graph represent the chromatogram after loading the columns with spark tholin treated first with NH_4OH solution. The protein amino acids have been identified with their names.

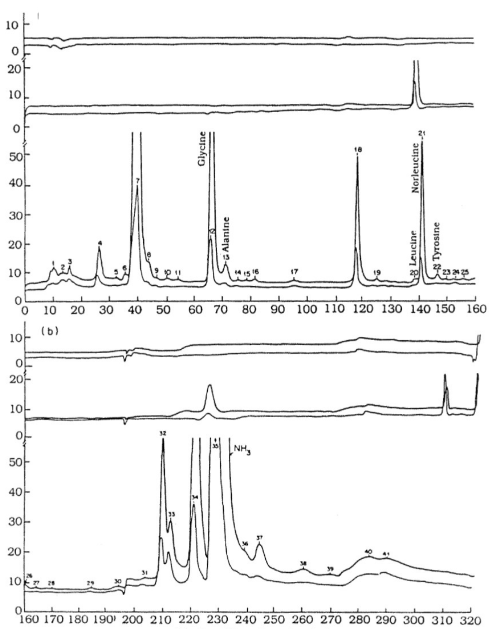

Figure 1. Chromatogram obtained in the analysis of spark tholin after treatment with pH 13 NH_4OH solution for a period of 30 hours at room temperature.

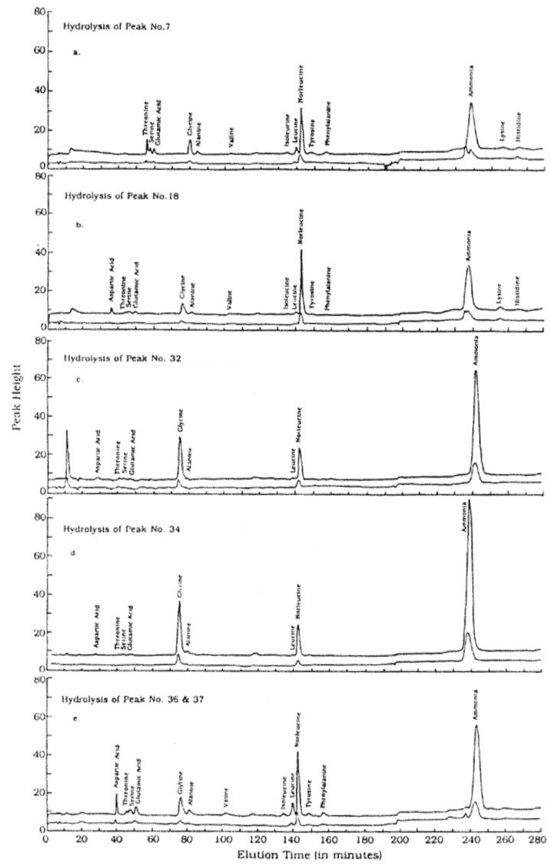

Figure 2. Chromatogram showing amino acid analysis of the hydrolyzed combined amino acid peaks. Upon hydrolysis, each of the five peaks (a-e, corresponding to peaks marked 7, 18, 32, 34, 36+37, and 38+39+40+41 in Figure 1) breaks down into its constituent amino acids. The peaks that could be identified as protein amino acids are labeled. Norleucine was added as a control in all cases.

Conclusion: These results clearly indicate that the interaction of organic matter on the moons with their respective liquids is very promising to find signatures of past or present life.