

**INCORPORATION OF NITROGEN INTO ORGANICS PRODUCED BY FISCHER-TROPSCH TYPE CHEMISTRY.** A. S. Burton<sup>1</sup>, T. McCollom<sup>2</sup>, C. Lee<sup>3</sup>, and E. L. Berger<sup>4</sup>; <sup>1</sup>NASA Johnson Space Center, Houston, TX ([aaron.burton@nasa.gov](mailto:aaron.burton@nasa.gov)), <sup>2</sup>University of Colorado at Boulder, Boulder, Colorado, <sup>3</sup>Lunar and Planetary Institute, USRA, Houston, TX; <sup>4</sup>Texas State University, San Marcos, TX — Jacobs JETS contract — NASA Johnson Space Center, Houston, TX.

**Introduction:** Laboratory simulations have demonstrated that hydrothermal systems have the potential to produce a range of organic compounds through Fischer-Tropsch type (FTT) chemistry [1,2]. The distribution of products depends on several factors, including the abundance and composition of feedstock molecules, reaction temperature, and the physical and chemical characteristics of catalytic materials included in the reactions. The majority of studies performed to date have focused solely on inclusion of CO<sub>2</sub> or CO and H<sub>2</sub> as the carbon, oxygen and hydrogen sources, which limits the possible products to hydrocarbons, alcohols and carboxylic acids [1, 3–5]. A few studies have included nitrogen in the form of ammonia, which led to the production of amino acids and nitrogenous bases [6, 7]; and a separate suite of studies included sulfur as sulfide minerals or H<sub>2</sub>S [8–11], which yielded products such as thiols and amino acids. Although these demonstrations provide compelling evidence that FTT reactions can produce compounds of interest for the origins of life, such reactions have been conducted under a very limited range of conditions and the synthetic reaction mechanisms have generally not been well-characterized. As a consequence, it is difficult to extrapolate these results to geologic systems or to evaluate how variations in reactant compositions would affect the distribution of products over time. We have begun a series of laboratory experiments that will incorporate a range of precursor molecules in varying compositions to determine how these variables affect the relative amounts and speciation of life-essential elements in organic molecules produced under FTT conditions. In the present work, we focus on systems containing C, H, O and N.

**Methods:** Reaction mixtures contained CO (~60–80 mM), 150 mM ammonium chloride, and water with a native iron catalyst, which also served as a source of H<sub>2</sub> through the reduction of water. Three initial experiments were conducted at 110, 154 and 185 °C and heated for several days. Following the reaction, a portion of the aqueous phase was removed and preserved for analysis, and then the remaining fluid and reaction vessel were extracted with dichloromethane (DCM). The DCM extracts were analyzed directly by gas chromatography-mass spectrometry, as well as undergoing derivatization with N,O-

Bis(trimethylsilyl)trifluoroacetamide (BSTFA) to permit analysis of less volatile DCM-soluble compounds. The preserved aqueous phase is currently undergoing analysis for polar compounds including amino acids and amines by liquid chromatography-mass spectrometry.

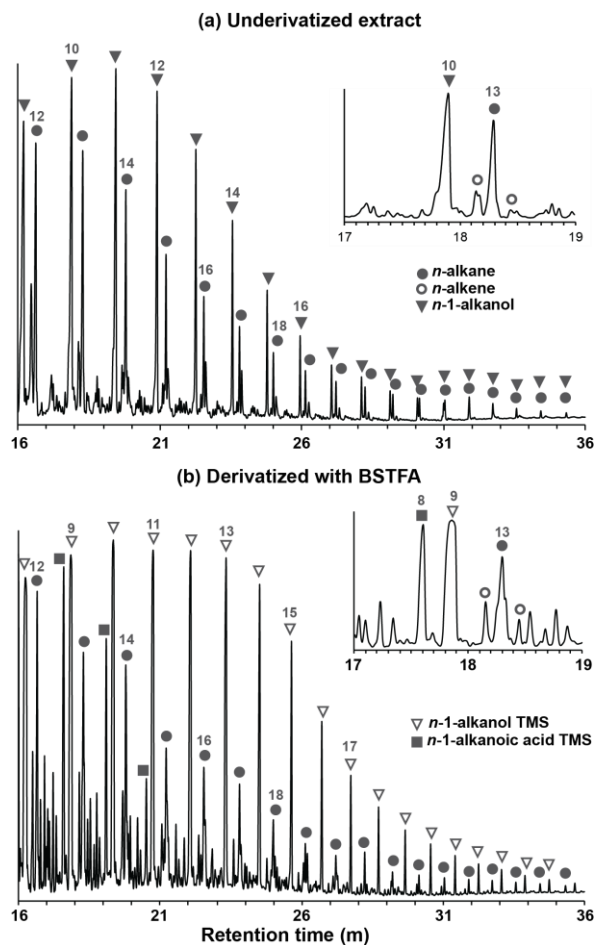
**Results:** Analyses of the DCM extracts of the 154 °C reaction solution phase revealed typical FTT distributions of products, including homologous series of *n*-alkanes, *n*-alkenes, and *n*-1-alkanols (Figure 1a); BSTFA derivatization of the extracts also revealed the production of a homologous series of *n*-alkanoic acids as well as the predominance of *n*-1-alkanols among the products (Figure 1b). The reaction performed at 110 °C yielded much lower amounts of products overall, but one notable result is that *n*-2-alkanones were found to be the most abundant solvent extractable product (Figure 2). GC-MS analyses with and without derivatization of the remaining reactions, along with LC-MS analyses of all samples, are underway.

**Conclusions:** FTT reactions containing significant abundances of N in the form of ammonium chloride yielded typical suites of alkanes, alkenes, alkanols and alkanolic acids. A reaction performed at a significantly lower temperature than normally used for FTT reactions contained an observably different product distribution predominated by 2-alkanone. No nitrogen-bearing compounds were observed in the DCM-soluble fractions extracted from the FTT aqueous phases, but these compounds will be searched for in the aqueous phases themselves.

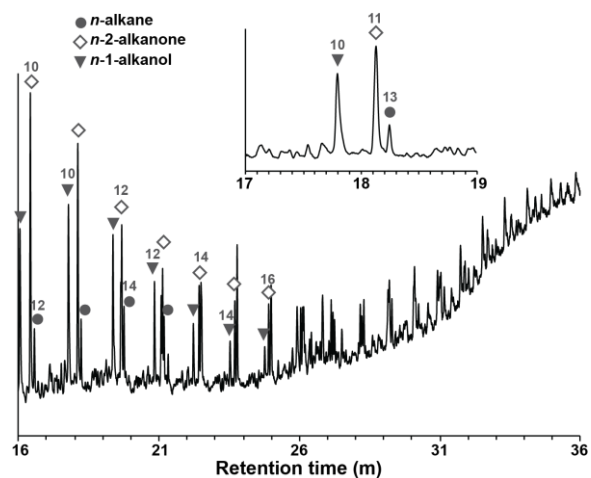
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**Figure 1.** Total ion chromatograms of compounds extracted from the 154°C FTT experiment analyzed either (a) underivatized or (b) derivatized with BSTFA using GC-MS. Symbols identify members of homologous series of *n*-alkanes, *n*-1-alkanols, *n*-1-alkanol trimethylsilyls (TMS), and *n*-1-alkanoic acid TMS. Numerals identify the number of carbons present in selected compounds. Insets show expanded views of the 17-19 minute region.



**Figure 2.** Total ion chromatogram of underivatized compounds extracted from the 110°C FTT experiment. Note relative predominance of a homologous series of *n*-2-alkanones relative to *n*-alkanes and *n*-1-alkanols of equivalent carbon number.