

A First Attempt to Simulate the Natural Formation of Meteoritic Organics Kathryn Gardner^{1,2}, Jean Li^{2,3}, Jason Dworkin², George D. Cody⁴, Natasha Johnson^{2,5} & Joseph A. Nuth III² (¹University of Oklahoma, Norman, OK & NASA-Undergraduate Student Research Program. ²Code 691 NASA-Goddard Space Flight Center, Greenbelt MD 20771. ³Columbia University, New York, NY. ⁴Geophysical Laboratory, Carnegie Institution of Washington, 5251 Broad Branch Rd., N.W, Washington, DC 20015. ⁵NAS/NRC Resident Research Associate)

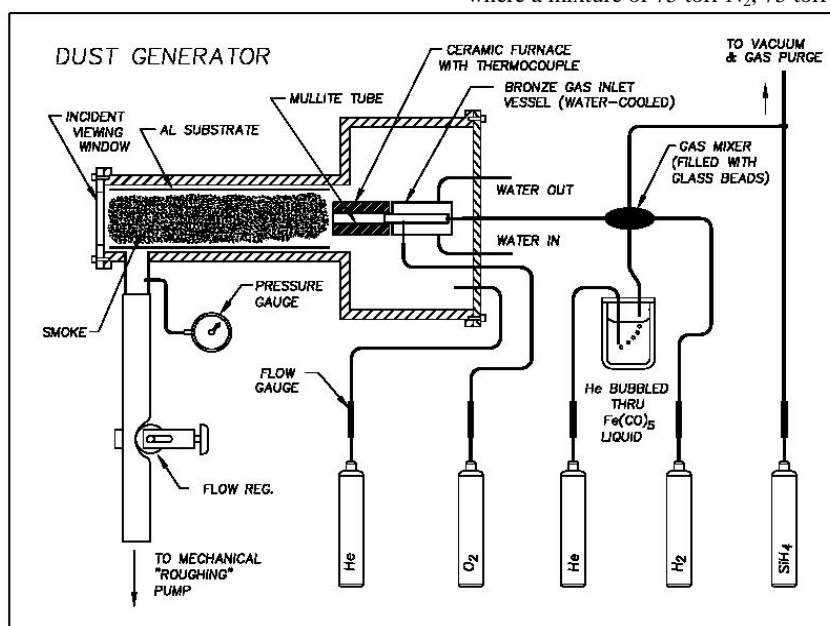
Introduction: Our working hypothesis in these experiments is that meteoritic organics are a mixture of materials made both in the interstellar medium and in the solar nebula that were further processed within meteorite parent bodies to produce what we see today. The material synthesized in the pre-solar environment is currently under study in several laboratories [1,2], though to our knowledge none are investigating the changes that might occur as the result of metamorphic processes on the parent body itself. Material made in the Solar Nebula results from a Fischer-Tropsch type (FTT) synthesis as CO and H₂ react on grain surfaces to make methane, as well as more complex species. The products of these reactions using 'natural catalysts' have been well-studied [3] and a calculation of the potential efficiency of FTT reactions in the solar nebula demonstrates that they could contribute significantly to the composition of material near 3 AU [4].

Our working hypothesis differs in three significant ways from past attempts to simulate the formation of organic materials as might have occurred in the Solar Nebula as the result of FTT reactions. First, we use a highly reactive iron silicate smoke as our analog 'natural' catalyst. We have argued [5] that such material is much more like the dust in protostellar sources than were the catalysts used in previous FTT studies, such as finely ground iron or chondritic meteorites. Second, we are not particularly interested in the gas phase products of the FTT reactions. Instead, we are interested in the carbonaceous gunk that gradually builds up on the grain surface; material previously thought to poison the catalyst and stop the reaction. We believe this material to be the original solar

nebula contribution to the meteorite parent bodies. Finally, some of us have argued that there is significant evidence suggesting that material can be circulated from the higher pressure and temperature environment of the inner nebula out to the region where comets may begin to form [6,7]. This, coupled with thermally driven circulation cells both above and below the nebular midplane, increases the likelihood that FTT products could interact many times with grain surfaces. Our experiment therefore continuously circulates both FTT products and our initial reactants (CO, N₂ & H₂) through the grains to make our final coated grains.

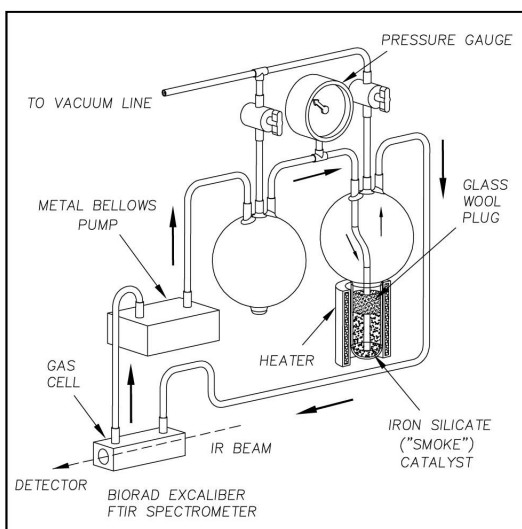
In what follows, we briefly describe the method used to generate our iron silicate smokes and their use in our simple catalytic system. We then describe the average characteristics of the organic materials deposited on our grains via this process [8] produced at a variety of temperatures ranging from 475K to 875K in a succession of experiments. Finally, we will describe the new FTT experiments carried out over the past year, the results of these new studies, as well as the preliminary results of the metamorphism of these organics as the result of thermal annealing and hydration.

Experimental Detail: Amorphous iron silicate smokes are produced in a hydrogen flow from a mixture of iron carbonyl and silane that reacts with oxygen in a furnace held at about 775K [5]. The reactants pass through a hydrogen flame front (T>1300K) in the furnace then are rapidly quenched as they pass into the collection region maintained at T<275K. The smokes collected from the Dust Generator (see below) are then transferred to the FTT catalyst experiment (below) where a mixture of 75 torr N₂, 75 torr CO and 550 torr H₂



can be passed through the dust at controlled temperature.

FTT Catalyst System



Preliminary analysis of the organics deposited on similar catalysts during 20 FTT experiments carried out at different temperatures ranging from 475K to 875K were reported at the last LPSC [8]. In general, the carbon in the grain coatings comprised roughly 10% of the total grain mass while total nitrogen was about 0.2% of the total mass. The organics were a mixture of both short and long-chain aliphatic compounds as well as a variety of simple and multi-ringed aromatic hydrocarbons. Functional groups observed included nitriles, cyano groups, ketones, aldehydes, and acids. Overall, the distribution of aromatic nitriles was very similar to that observed in the Tagish Lake meteorite [8].

New Experiments: Because the previous experiments were carried out over a range of temperatures in order to measure the rates and activation energies of the FTT reactions we have no information on the grain coatings produced at various temperatures. To remedy this situation we performed a set of 20 catalyst runs using our standard mixture of N_2 , CO and H_2 at 875K using the same amorphous iron silicate catalyst. We then performed a second set of 20 runs with this same gas mixture and a new catalyst at a temperature of 675K. Preliminary analysis indicated that the deposit at 875K consisted primarily of insoluble carbon, most likely polyaromatic hydrocarbons. In contrast, the deposit at 675K consisted primarily of soluble carbon compounds, and contained few insoluble materials. More complete analyses of these materials will be given in our poster.

Since we decided that we wanted a mixture of both soluble and insoluble compounds in our first hydration and thermal metamorphism experiments, we ran a very large sample of

amorphous silicate catalyst through 40 experimental runs at 775K to produce a large quantity of similarly coated, reactively altered grains. One third of this material was divided into subsets and allowed to react in liquid water at several different temperatures. In all cases, the material was allowed to react until it had dried out thoroughly so as to avoid fractionating the soluble components. Another third was divided and annealed under vacuum at 875K for various times. The results of these experiments will be reported in our poster.

References: [1] Greenberg J. M. (1996) *The Cosmic Dust Connection* (Kluwer, Boston) and references therein. [2] Hudson R. L. and Moore M. H. (2001) *JGR-Planets* 106, 33,275 - 33,284. [3] Hayatsu R. and Anders E. (1981) *Top.Curr.Chem* 99, 1 - 37. [4] Kress M. E. and Tielens A. G. G. M. (2001) *MAPS*, 36, 75 - 91. [5] Nuth J. A., Rietmeijer, F. J. M. and Hill H. G. M. (2002) *MAPS* 37, 1579 - 1590. [6] Hill H. G. M., Grady C. A., Nuth J. A., Hallenbeck S. L. and Sitko M. L. (2001) *Proc. Natl. Acad. Sci.* 98, 2182 - 2187. [7] Nuth J. A. (2001) *American Scientist* 89, 230 - 237. [8] Gilmour I., Hill H. G. M., Pearson V. K., Sephton M. A. and Nuth J. A. (2002) *LPSC 33, Abstract #1613*.