EXPERIMENTAL STUDIES OF PRE-SOLAR GRAIN ANALOGS: J. Nuth¹, R. Nelson¹,², M. Thiemens³, and B. Donn⁴; 1 - Code 691 NASA/GSFC, Greenbelt, MD 20771; 2 - Chemistry Department, Georgia Southern College, Statesboro, GA 30460; 3 - Chemistry Department, UCSD, LaJolla, CA 92039; 4 - Code 690, NASA/GSFC, Greenbelt, MD 20771.

Results reported in this abstract reflect work on four separate research tasks: production and characterization of amorphous smokes containing Fe, Al, Ti, Si, O and Cl; measurement of thermal and hydrothermal alteration effects in these smokes; measurement of oxygen isotopic fractionation during condensation of refractory grains; measurement of the rare gas trapping efficiency of silicate condensates. A flow condensation apparatus has been constructed at GSFC in which relatively large quantities of refractory smokes can be produced under controlled conditions. A gas flow, containing reproducible fractions of Fe(CO)₅, Al(CH₃)₃, TiCl₄, SiH₄ and O₂, enters a cylindrical furnace heated to temperatures in excess of 1500K, reacts and expands into a room temperature chamber where particle condensation and growth occurs. The chemical composition of the resultant smokes is determined via electron microprobe and the infrared spectrum of each sample is recorded using a Perkin Elmer FTIR spectrometer. Spectra of the pure end member amorphous smokes, (i) AlOₓ, (ii) FeOₓ, (iii) TiOₓ, and (iv) SiOₓ, have been obtained as have the spectra of selected combinations of these oxides up to and including FeₐAlₐTiₐSiₐOₓ. These spectra will be presented and discussed. In addition, we will discuss the changes observed in the infrared spectra of samples immersed in liquid water at 375K for 95 hours and the spectral changes induced by vacuum annealing at 1000K and 1200K for 1, 2, 4, 8, and 16 hours. The oxygen isotopic compositions of three smoke samples which were produced in the flow condensation apparatus have been analyzed to date at UCSD. Each of these samples shows significant oxygen isotopic fractionation. Sample one (31% Al₂O₃, 69% SiO₂) has a δ¹⁸O of -26.2 per mil, δ¹⁷O of -13.4 per mil compared to the starting composition.
Sample two (23% Al$_2$O$_3$, 70% SiO$_2$, 7% FeO) has a delta$^{18}$O of -27.0 per mil, delta$^{17}$O of -13.9 per mil. Sample three was produced by a flow through an unheated furnace tube in the flow condensation apparatus. During this experiment, spontaneous explosive reaction occurred at random intervals in a room temperature gas (the heater burned out just as the experiment began); the composition of this sample was higher in silica (12% Al$_2$O$_3$, 85% SiO$_2$, 3% FeO) and less fractionated: delta$^{18}$O of -20.6 per mil, delta$^{17}$O of -10.6 per mil than those produced at higher temperatures. Further experiments are in progress to try to identify the chemical species responsible for the fractionation and the mechanism by which it occurs.

Isotopic measurements are also being made on the products of the vacuum annealing and hydrothermal alteration experiments in order to quantify the lifetime of such isotopically labeled amorphous smokes. Measurements of the quantity and isotopic composition of Kr and Xe trapped in Si$_2$O$_3$ smokes (produced in our old crucible evaporation system (Nuth and Donn, Proc. LPSC XIII, JGR, Red, 88 A847) in H$_2$ at 35 torr total pressure to which 10, 100 and 1000 microns of a rare gas mixture had been added) were performed at the McDonnell Center for the Space Sciences by Dr. Charles Hohenberg's group. Samples were condensed at both high (T > 1000K) and low (T < 750K) temperatures; the noble gas mixture contained 65% Argon, 28.2% Neon, 5.5% Krypton, and 1.3% Xenon. A large amount of residual Argon was trapped in the samples, thus preventing the acquisition of useful data for Argon; similarly doubly charged CO$_2$ interfered with the Neon measurements. For Krypton and Xenon, the amount of trapped gas in the samples was roughly proportional to the partial pressure of the rare gas in the ambient atmosphere: ~1x10$^{-7}$ ccSTP/g $^{84}$Kr and ~6x10$^{-8}$ ccSTP/g $^{132}$Xe were trapped at Kr and Xe partial pressures of ~7x10$^{-5}$ atm and ~2x10$^{-5}$ atm, respectively. No isotopic fractionation of either rare gas was observed nor was there a detectable difference in the concentration of the gas trapped at high and low temperatures. This would suggest a physical trapping mechanism during particle growth rather than the establishment of an equilibrium "solution" within the grains. Stepped heating experiments are currently in progress in order to see how tightly the gas is bound in these amorphous smokes.