Investigation of Chemistry at Ice-Mineral Interfaces of Phosphorus-Containing Meteorite Analogues

The search for life outside of Earth has raised questions about how life began have intrigued origin-of-life researchers, such as the incorporation of phosphorus into biomolecules. Phosphorus exists on Earth mostly as phosphate, PO_4^{3-}, which is insoluble and unreactive in the geochemical conditions of the early Earth. The challenge of incorporating phosphorus into biomolecules is known as the “phosphorus problem,” prompting investigations of reactive phosphorus species delivered to the prebiotic Earth. Phosphorus-laden meteorites delivered schreibersite $(Fe,Ni)_3P$, a possible mineral source of phosphorus recognized for its redox chemistry potential and observed reactivity with aqueous solutions. This thesis work aims to better understand the chemical reactions occurring on the schreibersite inclusions on comets and meteorites and will focus on 1) identifying potential prebiotic phosphorus species formed at the ice-mineral interface of schreibersite, and 2) the energy requirements necessary for the abiotic formation of phosphorus-containing compounds. Specifically, the reactions of water and methanol ices on a schreibersite analogue will be investigated upon heating and irradiation with tuneable, low-energy electrons in ultrahigh vacuum conditions, utilizing reflection-absorption infrared spectroscopy (RAIRS) to measure changes in surface structure and mass spectrometry (MS) to analyze species desorbing from the mineral surface. These experiments attempt to identify abiotic pathways in which phosphorus is incorporated into prebiotic reactions, and are intended to provide reference spectra for solar system mission data. Preliminary results obtained from these experiments will be presented.

Key Words: Phosphorus, Origin-of-life, Astrochemistry, Astrobiology, Schreibersite, Spectroscopy, RAIRS, Surface Chemistry