127. Investigations into the Astrochemistry of H_2O_2, O_2, and O_3 in Ion-Irradiated Ices

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Features due to solid-phase H_2O_2, O_2, and O_3 have been found in the reflectance spectra of some of the icy satellites of Jupiter and Saturn (Spencer et al., 1995; Spencer and Calvin, 2002; Noll et al., 1996; Noll et al., 1997; Carlson et al., 1999). These molecules can form by high-energy bombardment of magnetospheric ions. This radiation breaks chemical bonds in the ice, forming species that can react to produce new molecules. Gravitational loss of H_2 then leaves an oxygen-rich ice containing H_2O_2, O_2, and O_3.

In the Cosmic Ice Laboratory at NASA-Goddard we have studied these processes by using 0.8 MeV protons to irradiate ices containing H_2O_2, O_2, and O_3. We are able to measure rates of molecular formation and destruction, and IR spectra as a function of temperature, sample concentration, and radiation dose. In this poster we show some of our most-recent results on the radiation chemistries of H_2O, H_2O_2, O_2, and O_3, such as the formation of the HO_3 radical in these ices.

References

137. Geologic Radionuclide Energy Transfer Processes on the Early Earth

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Radioactive mineral seams and beaches, by virtue of their elemental associations, entropy of energy transfer, diversity of reactant phases, decay history, geochemical concentration, and geophysical arrangement, demonstrate tremendous potential as having formed the organic materials necessary for the origin or support of the first life on Earth. Energy transfer from incident radionuclide decay particles is an extremely localized, low-entropy, stochastic process, thus necessitating long geologic timescales for significant product yield. These timescales, while feasible for geologic structures occurring in a natural environment, make analogue laboratory efforts difficult without highly contrived setup parameters. But in theory, these timescales may also allow for energy transfer mediation pathways to the chemical potential state that have been overlooked for geologic settings. One such pathway is addition- or cyclization-radical reactions through dissociated monatomic nitrogen hydrogen abstraction, which could reduce overpolymerization and cross-linking of the reaction products.

Previous papers have described the evidence concerning a radioactive origin of life (Miller and Urey, 1959; Glover, 1992; Parnell, 2003) but there are no reported long-timescale laboratory investigations, nor systematic physical or chemical treatment, of the energy transfer process as it would occur in a geologic setting. This effort will outline the peril and the promise of investigating radioactive nuclide energy transfer to the chemical state on the early Earth and comparable terrestrial planets.

141. Biological In Situ Resource Utilization (BISRU) on Mars: Artificial Biosphere Growth and Stability on Manned Mars Missions

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The latest remote investigations of the surface of Mars indicate a surface comprised of nearly all elements that comprise a terrestrial biosphere: carbon (as atmospheric CO_2), hydrogen and oxygen (as subsurface water ice and as a small fraction of atmospheric water vapor), nitrogen (as atmospheric N_2), and sulfur (as sedimentary sulfates). While such reservoirs comprise limited redox states of each element, it is possible that carefully designed bioregenerative life support systems incorporating a range of interdependent metabolic strategies (similar to ESA’s MELiSSA project) could uptake small fluxes of these reservoirs and convert them to biologically assimilable organic materials. With sufficient energy input, element temperature and pressure maintenance, careful control of nutrient fluxes, and additional trace nutrients transported from Earth (namely phosphorus), astronauts could drive biosphere growth through elemental cycling after arriving on Mars.

The ultimate goals are to diversify the energetic pathways of the biosphere, increase the amount of biologically assimilable material in the artificial biosphere beyond that which can be carried from Earth, and foster increased system robustness on long mission time scales. This could help relieve dependence upon re-supply missions from Earth, and promote more responsible logistical support of an exploratory base on the surface of Mars by reducing overall influx of non-indigenous materials.