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Radiation Induced Chemistry of Icy Surfaces: Laboratory Simulations

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Abstract

We will discuss laboratory experiments designed to enhance our understanding the chemical processes on icy solar system bodies, enable interpretation of in-situ and remote-sensing data, and help future missions to icy solar system bodies, such as comets, Europa, Ganymede, Enceladus etc.

1. Introduction

Radiation, in the form of electrons, protons, ions, and photons continuously bombards surfaces of bodies in our solar system [1-4]. This radiation causes not only physical changes of the icy surfaces, but it also induces and controls chemistry of and in these ices. For example, intense magnetospheric electron and ion bombardment of Jovian and Saturnian icy satellites such as Europa and Iapetus results in highly contrasting dark regions on these icy moons. Corotation with the Jupiter's magnetic field causes Europa's trailing hemisphere to receive more flux of energetic electron and plasma ion radiation than the leading hemisphere. As a consequence of electron bombardment, surface of the trailing hemisphere of Europa is heavily processed [5-8]. In the context of potential sub-surface oceans and suitable habitable regions [9-11], it is important to understand how such electron irradiation would process biologically relevant species at the icy surface of these satellites such as Europa and how deep the life/organics be beneath the surface in order to be protected from the radiation. Radiation processing of comet and asteroid surfaces also plays a crucial role in the evolution of these small solar system bodies [12-14].

In order to understand these processes, interpret the observational data, and help frame future investigations (and missions), it is critical to have comprehensive laboratory experimental and theoretical research focused on planetary sciences and astrophysics. Our laboratory focuses on understanding surfaces and atmospheres of icy bodies such as comets, Europa, Enceladus as well as organic-rich environments such as Titan. Here we present our research on laboratory studies for icy solar system bodies.

2. JPL's Ice Spectroscopy Lab (ISL)

At the *Ice Spectroscopy Lab (ISL)* of JPL, we investigate physics and chemistry of ices that are relevant to interstellar medium, solar system, and Earth sciences. Unique aspect of our laboratory is to conduct *simultaneous* spectroscopic studies on the ice probes – by bringing the spectroscopic instruments to the ice probe than the ice to the spectroscopic instruments. Over the past few years we developed the ISL's capabilities to conduct experiments on ices from ~5 K and above, from 100 nm to 500 microns (vacuum ultraviolet, VUV, to far infrared, FIR); radiation processing using electrons, protons, VUV discharge lamps, and tunable lasers; laser-ablation and temperature programmed desorption (TPD) mass spectroscopic analysis.

Our focus is to understand the nature of amorphous and crystalline surface ices and how their physical properties such as porosity, thermal and electrical conductivity influence radiation-induced chemistry in these ices. In particular we would like to understand conditions under which organics and biomolecules – markers of potential life – get synthesized in extraterrestrial conditions and survive. Our research is also focused on understanding the evolution of ice and organics on comets and asteroids.

In this talk we will give a general outline of the *Ice Spectroscopy Lab* activities and discuss our recent results on electron induced damage to organics in ices.

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References

1. Cooper, J.F., et al., *Energetic ion and electron irradiation of the icy Galilean satellites.* Icarus, 2001. **149**(1): p. 133-159.
2. Cooper, J.F., et al., *Proton irradiation of Centaur, Kuiper Belt, and Oort Cloud Objects at Plasma to Cosmic Ray Energy.* Earth Moon Plan., 2003. **82**(1-4): p. 261-277.
3. Hudson, R.L. and M.H. Moore, *Radiation chemical alterations in solar system ices: An overview.* Journal of Geophysical Research-Planets, 2001. **106**(E12): p. 33275-33284.
4. Paranicas, C., et al., *The ion environment near Europa and its role in surface energetics.* Geophysical Research Letters, 2002. **29**(5): p. 4.
5. Tiscareno, M.S. and P.E. Geissler, *Can redistribution of material by sputtering explain the hemispheric dichotomy of Europa?* Icarus, 2003. **161**(1): p. 90-101.
6. Johnson, R.E., et al., *Europa's surface composition and sputter-produced ionosphere.* Geophysical Research Letters, 1998. **25**(17): p. 3257-3260.
7. Grundy, W.M., et al., *New horizons mapping of Europa and Ganymede.* Science, 2007. **318**(5848): p. 234-237.
8. McCord, T.B., et al., *Hydrated minerals on Europa's surface: An improved look from the Galileo NIMS investigation.* Icarus, 2010. **209**(2): p. 639-650.
9. Khurana, K.K., et al., *Induced magnetic fields as evidence for subsurface oceans in Europa and Callisto.* Nature, 1998. **395**: p. 777-780.
10. Pappalardo, R.T., et al., *Does Europa have a subsurface ocean? Evaluation of the geological evidence.* Journal of Geophysical Research, 1999. **104**(E10): p. 24015-24055.
11. Chyba, C.F. and C.B. Phillips, *Europa as an abode of life.* Origins of Life and Evolution of Biospheres, 2002. **32**(1): p. 47-68.
12. Cottin, H., M.C. Gazeau, and F. Raulin, *Cometary organic chemistry: a review from observations, numerical and experimental simulations.*

Planetary and Space Science, 1999. **47**(8-9): p. 1141-1162.
13. Groussin, O., et al., *Surface temperature of the nucleus of Comet 9P/Tempel 1.* Icarus, 2007. **187**(1): p. 16-25.
14. Vernazza, P., et al., *Solar wind as the origin of rapid reddening of asteroid surfaces.* Nature, 2009. **458**(7241): p. 993-995.