AN EXPERIMENTAL SET-UP FOR STUDYING THE CHEMICAL EFFECT OF IRRADIATION ON DIFFERENT PLANETS

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Introduction: Earth, Mars, Europa, Triton, and other bodies in our solar system are continually exposed to the effects of different types of irradiation. This radiation results in breaking and rearrangement of chemical bonds within ices and minerals, causing the destruction of some species and the creation of others (HCO, H_2CO, CH_4, CO_2, etc.). Furthermore, many of these species are of biological interest to understand the origin of life. For example, photochemical reactions, driven by solar UV, are believed to be the principal source of complex molecules observed in the most planetary and lunar atmospheres (1). The knowledge of the photochemical routes by which organics are formed in other planetary atmospheres could provide insights into photoproducts that were formed in the atmosphere of the primitive Earth.

Understanding the role played by different sources of radiation in chemical process on the planetary surfaces is relevant. Ionic energetic impacts could induce many effects on an icy surface, like chemical reactions, electrostatic charging, lattice damage, desorption and evaporation, some of which alter the appearance of the surface (2).

We have recently designed an experimental chamber for providing to the international scientific community with a highly versatile tool to simulate environmental conditions (partial gas pressure and temperature). The main technical characteristics of this equipment are:

- Total pressure range from 5 mbar to $5x10^{-9}$ mbar. Partial pressure of the gasses can be set with this precision.
- Temperature range from 4 K to 325 K
- Gas composition is regulated via a residual gas analyzer with ca ppm precision
- Sample size range from 5 to 35 mm
- Available irradiation sources: up to 5 KV-ions (ions) 5 KV-electrons, Deuterium UV lamp and noble-gas discharge UV.
- Analysis in-situ techniques: UV spectroscopy, infrared spectroscopy.

This system has been especially designed to evaluate the possible effect of irradiation on the surface of different planets and satellites.

The goal of this lecture is to present an overview of the technical capabilities of a recently build experimental system for simulating the environment of different planetary bodies and the chemical effect of irradiation from different sources. Also, prototypical experiments will be presented as an illustration for researchers interested in future applications

On the other hand we will present new and preliminary results about the attenuation of different irradiations on a particular surface induced by the atmosphere.

Experimental details: The experimental simulation system consists of an ultra-high vacuum (UHV) chamber 500 mm long by 400 mm diameter with standard CF flanges and fittings. Two sample holders made on copper 10 mm and 40 mm, respectively, are used to introduce different kind of samples in the chamber. Crystals, soils, rocks, minerals and biological samples are among the possible types that can be introduced. The sample holder is attached at the end of the transfer rod, those can be cooled by flushing Helium liquid through. A silicon diode measures the temperature range (from 4 K to 325 K).

The desired atmosphere conditions inside the chamber are created from a mixture of gases and water vapor dosed from the many-fold at the required gas proportion, controlled each by individual fluxmeters. Gas composition is constantly monitorized by a residual gas analyzer spectrometer. A water partial pressure can be also set and regulated.

Irradiation studies of the samples are performed by different sources: ions and electrons up to 5 KV, discharge UV (HeI) and Deuterium Lamps. Mass spectrometry, UV spectroscopy, infrared spectroscopy are used as analysis techniques.

Preliminary results: We have simulated Mars and Europa atmosphere. Mars atmosphere has been reproduced by including 95%CO_2, 2,7% N_2, 1.6% Ar and 0.6% H_2O composition, the average atmospheric pressure of the planet is 7 mbars and a temperature range from 150 to 280 K. To simulate Europa we have set 10^{-8} mbar just from O_2 and temperature ranging from 86 to 146 K are being used.

For those environmental conditions we have study the percentage of radiation that arrives to the surface. Attenuation of electronic and ionic irradiation depends on the electron and ion free-mean path, which is a function of the total gas pressure of the atmosphere and the energy of the incident particle. Minimum irradiation has been found for particle energies of about 100-200 eV . In the case of Mars, the presence of atmospheric gases absorbs the incoming particles and very little electrons and ions are measured to arrive to the surface in the experimentally available range of energies. However, this is not the case of Europa, where due to the low total pressure (10^{-8} mbar) electronic and ionic irradiation plays an important role in the surface chemistry (3,4). Therefore, this seems to be an important parameter to take into account when describing the geological process of the satellite.

This scenario is different when we talk about UV radiation. In this case the attenuation strongly depends on the atmosphere composition and on the radiation wavelength. We have *in-situ* recorded absorption curves both for Deuterium radiation in the range of 200-400 nm. and strong monochromatic HeI radiation at 58 nm.

Currently experiments devoted to record chemical changes due to these radiation effects are in progress. The analysis of these changes is performed ex-situ, although in the near future an IR-Spectrometer will be incorporated for *in-situ* monitoring of the changes.

Summary: The role of the ion, electron and UV radiation on chemical and physical properties of planetary surfaces has been studied by means of a versatile environmental simulation chamber, in which temperature and atmosphere can be accurately set.

References:

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