THE MOON IO AND SERENDIPITY Isodore Adler[1], Lo I. Yin[2], G. Coyle[1], and T. Tsang[3] [1]Dept. Chemistry, Univ. Maryland, College Park, MD 20742, [2]Goddard Space Flight Center, Greenbelt, MD 20771, [3]Dept. Physics and Astron., Howard Univ., Washington, DC 20059

In the last two years our laboratory has been involved in the study of the radiation effects of a generalized glow discharge on various types of sulfur compounds using X-ray photoelectron spectroscopy (XPS).[1] These studies have evolved from a consideration of the possible relationship between solar wind bombardment and lunar surface darkening.[2,3] Now as an extraordinary coincidence we find one solar system body, Io, in an environment closely approximating that which we have used in our investigations, i.e. a system involving the interaction of a plasma with the surfaces of various kinds of sulfur compounds. XPS has proved an invaluable tool in enabling us to follow the changes in the chemistry of both the sulfur and the cation. Examples of such interactions will be given below.

The Voyager I and II flybys established that Io is in a class of its own with regard to the scale of its volcanic activity and the startling appearance of its surface. The present observations point convincingly to a surface consisting essentially of sulfur in various allotropic forms as well as sulfur dioxide frozen out in the form of sulfur dioxide snow. One model proposed recently for the crust has an ocean of liquid sulfur overlain by a crust of solid sulfur and liquid sulfur dioxide capped finally by a layer of both solid sulfur and sulfur dioxide. Volcanic eruptions bring solid sulfur, sulfur dioxide gas and sulfur dioxide snow to the surface.

Spectroscopic data shows that Jupiter is surrounded by a torus of charged sulfur and oxygen ions for which Io is the source. The pathway by which the sulfur from Io becomes the torus around Jupiter is however not yet established and is the source of speculation. Finally, and very importantly, Io is deeply embedded in Jupiter's enormous magnetosphere. The charged particles in this magnetosphere are known to be accelerated to very high energies. Thus Io is subjected to charged particle bombardment which is a significant part of the argument in this paper.

Experimental Work

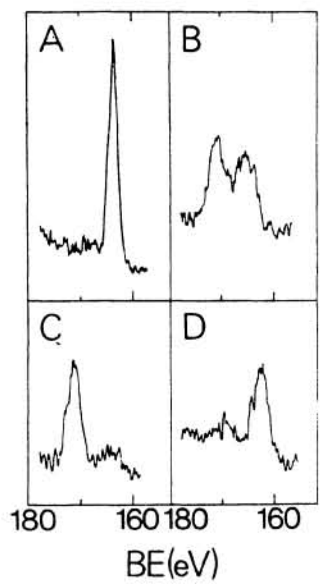
We have conducted a large number of experiments on a variety of sulfur compounds and sulfur, involving the taking of photoelectron spectra before and after a sequence of glow discharge ion bombardment procedures. This has enabled us to study the time-dependent and flux dependent radiation effects of the plasma on the sample. Not surprisingly, in view of the complex chemistry of sulfur and the complicated character of the interaction at the plasma-solid interface, a variety of results were obtained and some of these appear to be relevant to the Io problem.

What we have been able to establish from the very outset is that under ion bombardment of transition metal -sulfur compounds, the cation is often reduced to a lower valence state or metallic state. The mechanism for this process is most likely due to the plasma induced excitation of the valence electrons and/or ion-surface interactions.

In addition to the above compounds of sulfur we have also examined the effects of ion bombardment on elemental sulfur. Fig. 1 shows the results of a sequential bombardment of an elemental sulfur surface, first by oxygen ions and then finally by argon ions. The oxygen ion bombardment is seen to produce a higher oxide of sulfur. The subsequent argon ion bombardment produces what appears to be either elemental sulfur or some sulfur polyion. We feel that such phenomena has a direct bearing on the Io problem and may explain in part the strange coloration of the surface. Further ion bombardment stuides of a variety of sulfate compounds[4] has disclosed a behavior that varies all the way from a selective sulfur loss to the formation of complex sulfur polyions.

With regard to the plasma-surface interaction one can envision a scenario to explain the formation of the sulfur torus, around Jupiter where a possible contributing mechanism involves ionization of sulfur vapor at Io's surface which is then swept away by the charged flux of Jupiter's magnetosphere (analogous to the removal of the earth's early atmosphere by the early more intense solar wind). It is also obvious that there are a number of questions which can be further addressed by exploiting the experimental techniques we have been employing.

Fig. 1



S2*p* photoelectron spectra of pure sulfur under 1.5 kV oxygen ion bombardment. (A) Prior to bombardment (B) 4×10^{17} oxygen ions/cm^2 dosage (C) 1×10^{18} oxygen ions/cm^2 dosage (D) 5×10^{18} oxygen ions/cm^2 followed by 4×10^{17} argon ions/cm^2.

References:

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