

Europa' s Tenuous Sodium Atmosphere Formation and Surface Chemical Composition Uncovered by Plasma Irradiation Experiment on Sodium Sulfate

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Europa, one of Jupiter's icy satellites, is one of the bodies with possible life in their interior ocean. The transport of materials such as water and salt between the interior ocean and the surface layer has been proposed (Schubert et al., 2004). Understanding the chemical composition of Europa's surface material will lead to understating the chemical composition and habitability of the interior ocean environment (Schubert et al., 2004). Europa' s surface layer is exposed to Jupiter's magnetospheric plasma, which causes sputtering and other space weathering. While the sputtered particles produce a tenuous atmosphere, the chemical composition of the surface material is likely to change (Carlson et al., 2009). Hoshino et al. (in prep) successfully associated the Na tenuous atmosphere with surface composition based on plasma irradiation of NaCl and physical chemistry modeling. They estimated the total amount of Europa' s Na atmosphere based on the modeling (Leblanc et al., 2002) with a constraint of the surface Na sputtering rate. The total mass of Na atmosphere was estimated to be about 400 kg, which is half of the ground-based telescope estimation (Brown and Hill 1996). This suggests that Na sources other than NaCl, such as sodium sulfate (Na₂SO₄), are present on Europa's surface and contribute to the Na atmosphere. However, the Na sputtering rate from the surface Na₂SO₄ by Jupiter's magnetospheric plasma irradiation and the resultant Na atmospheric distribution are not quantified. Therefore, these are not quantitatively associated with each other yet, which prevents us from the demonstration of Na₂SO₄ on Europa' s surface.

Here, we irradiated Na₂SO₄ samples with charged particles under the same conditions as Hoshino et al. (in prep) and evaluated the Na sputtering yield. The samples were irradiated at room temperature with the electron at fluxes of 8.58E+14 and 8.87E+13, hydrogen ion, at fluxes of 9.42E+14 and 2.06E+14, and oxygen ion at fluxes of 4.63E+14 and 1.92E+13, for 90 minutes, respectively. The Na sputtering yield was found to be 2.7E-04 /incident particle and 5.56E-04 /incident particle for electrons, 2.5E-04 /incident particle and 8.29E-04 /incident particle for hydrogen ions, and 7.4E-03 /incident particle and 8.81E-04 /incident particle for oxygen ions. This result was sufficiently smaller than the yield of the NaCl experiment (Hoshino et al. in prep), and the contribution of Na₂SO₄ to the Na atmosphere of Europa is predominantly small. The dependence of yield on the incident flux was estimated to be negatively correlated for all incident particles. Extrapolating the obtained dependence, the yield on Europa' s surface was estimated to be 5.9E-04 /incident particle for electrons, 9.9E-04 /incident particle for hydrogen ions, and 9.8E-03 /incident particle for oxygen ions. Currently, a temperature control system is being developed to maintain irradiation samples at Europa' s surface temperatures (80~100 K). With this control system, we are going to obtain the sputtering yield under realistic temperature conditions and then constrain the Na atmospheric modeling. In this presentation, the current status of our research will be reported.

Keywords: Europa, Icy satellites, Irradiation Experiment