Constraint of salt compositions on Europa's surface from observations using Subaru telescope and laboratory experiments

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The surface of Europa has been recently observed in wavelength of 1.5-2.5 μm with large ground-based telescopes, Keck and VLT (Fischer et al., 2015; Ligier et al. 2016). Those observed reflectance spectra suggest that the existence of chlorides on Europa's geologically active regions, called chaotic terrains. Although those salts would reflect the chemical compositions of the subsurface ocean (e.g., Zolotov et al., 2009), the detailed compositions (i.e., cations and redox state) are not well constrained due to the lack of observations with wide wavelength ranges. Chlorides on the surface could experience dehydration or oxidation to form oxychlorines, such as perchlorates, triggered by irradiations of UV and high-energy particles (e.g., Johnson et al., 2019). However, those are poorly investigated based on laboratory experiments.

Here, we perform high-spectral observations for Europa's surface in the wavelength of 0.95-1.5 μm using the Subaru telescope and IRCS. This provides reflectance spectra of the surface with high-spatial resolution of 200-400 km/pixel, including chaotic terrains. Our results show no remarkable peaks of hydrated salts in the observed spectra. This strongly suggests that surface salts are anhydrous sodium chlorides (e.g., NaCl and/or $NaClO_4$).

We also conduct laboratory experiments to simulate irradiations for surface hydrochlorides at low temperatures. We irradiated UV or electron (~10 keV) onto mixtures of H_2O ice and chlorides (NaCl) at low temperatures (~100 K) using a high-vacuum experimental system. In addition, irradiated higher-energy electron (~2.0 MeV) onto frozen salt solutions with the pulsed power generator “ETIGO-III” (Tokuchi et al., 1998). Our preliminary results show no clear evidence of formation of oxychlorines from NaCl or its mixture with H_2O ice. Given the dose rate of electron onto Europa's surface (Paranicas et al., 2009), the irradiation doses in the experiments correspond to < ~100 years on the surface. These results suggest that little oxychlorines would be formed in chaotic terrains in this short timescale.

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