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Abiotic production of iodine molecules in irradiated ice

Wonyong Choi (1), Kitae Kim (2), and Akihiro Yabushita (3)

(1) School of Environmental Science and Engineering, Pohang University of Science and Technology, Pohang, Korea (wchoi@postech.edu), (2) Korea Polar Research Institute, Incheon, Korea, (3) Department of Molecular and Material Sciences, Kyushu University, Fukuoka, Japan

Reactive halogen species play an important role in Earth's environmental systems. Iodine compounds are related to ozone depletion event (ODE) during Antarctic spring, formation of CCN (cloud condensation nuclei), and controlling the atmospheric oxidizing capacity. However, the processes and mechanisms for abiotic formation of iodine compounds in polar region are still unclear. Although the chemical reactions taking place in ice are greatly different from those in aquatic environment, reaction processes of halogens in frozen condition have rarely studied compared to those in water. In this study, we investigated iodide oxidation to form triiodide (I3-) in ice phase under UV irradiation ($\lambda > 300$ nm) and dark condition. The production of I3- through iodide oxidation, which is negligible in aqueous solution, was significantly accelerated in ice phase even in the absence of UV irradiation. The following release of gaseous iodine molecule (I2) to the atmosphere was also monitored by cavity ring-down spectroscopy (CRDS). We speculate that the markedly enhanced iodide oxidation in polycrystalline ice is due to the freeze concentration of iodides, protons, and dissolved oxygen in the ice crystal grain boundaries. The experiments conducted under ambient solar radiation of the Antarctic region (King George Island, 62°13′S 58°47′W, sea level) also confirmed that the generation of I3- via iodide oxidation process is enhanced when iodide is trapped in ice. The observed intrinsic oxidative transformation of iodide to generate I3-(aq) and I2(g) in frozen environment suggests a previously unknown pathway for the substantial release of reactive iodine species to the atmosphere.