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Formation of iodine oxide aerosol from the photooxidation of iodomethane: Chemical and physical characterization

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Gas phase reactions of volatile iodinated organic compounds (VIOCs) are important in the field of nuclear industry safety to better assess chemical processes responsible for the formation of primary and secondary fission products that may be released into the natural environment if a major nuclear power plant accident type Fukushima, Japan, or Chernobyl, Ukraine, were to occur. The products of VIOC oxidation processes in the presence of free radicals, namely O(^{3}P) atoms and ·OH radicals, include iodine oxides (IxOyHz) that are well known to form aerosols. However, to date, the mechanisms and kinetics of many VIOC destruction and formation processes remain uncertain or poorly understood. Iodine oxide particle production is thought to involve the recombination reactions of IO/OIO radicals to form higher iodine oxides which lead to homogeneous nucleation and particle growth. However, the current understanding of these processes remains incomplete and there is little information available in the literature on the final composition of aerosols, size distribution and morphology under atmospheric and accident conditions. This is worrisome because the physical and chemical characterization of iodine oxide aerosols is crucial to better predict trapping efficiencies of nuclear power plant filters and to predict how much organic and iorganic iodine would be released into the environment if the containment building barrier wall were to be fractured or if the containment building had to be depressurized in emergency. Atmospheric chamber simulation studies that investigate the aerosol formation resulting from photooxidation of CH3I have been carried out. The experiments were performed using UV-B radiation as a function of different ozone mixing ratios and relative humidities. The size distribution and chemical composition of formed aerosols were monitored using SMPS and HR-ToF-AMS, respectively. Gas phase time profiles of VIOCs were determined using the PTR-TOF-MS technique. The results showed an important particle formation as soon as the CH_3I was introduced into the chamber in the presence of radiation, ozone and humidity. Off-line TEM-EDX analyses were also performed to study particles morphology and elemental composition. The obtained results show that the change in relative humidity does not affect the photolysis rate of CH_3I but has an impact on the particle number and mass concentration. The obtained results suggest a potential role of the ·OH radicals on the formation of iodine oxides and the role of water on particle growth. Aerosol chemical analyses reveal that the particles are fractal and mainly composed of different forms of HxIyOz compounds. The influence of irradiation, O_3 concentration, CH_3I concentration and relative humidity on aerosol formation is discussed. The obtained results will help the scientific community to develop new models and mitigation techniques to limit human health risks in case of an important organic and inorganic iodine release from a nuclear power plant.