Investigation on new particle formation competing against the growth of pre-existing particles during isoprene ozonolysis

*Satoshi Inomata[1], Jun Hirokawa[2]

1. National Institute for Environmental Studies, 2. Hokkaido University

Atmospheric aerosols scatter and absorb incoming solar radiation, which directly impact the global radiative balance of the atmosphere. If these aerosols are hydrophilic, they can act as cloud condensation nuclei (CCN) and have an indirect effect on the climate by modifying the properties of clouds. New particle formation (NPF) through nucleation is believed to contribute up to half of the global CCN concentrations. The nucleation and growth mechanisms of new particles in the atmosphere have therefore been topics of study in atmospheric research. Recently, we observed NPF during ozonolysis of small alkenes such as isoprene and ethene even in the presence of seed aerosol. We proposed that oligomeric hydroperoxides originated from stabilized Criegee intermediates (sCIs) that were generated during the ozonolysis of the small alkenes potentially contribute to the NPF while competing with the uptake into pre-existing particles. To evaluate quantitatively whether this type of NPF is important in real atmosphere, we have tried to estimate an “yield of the NPF (y^{NPF}) competing against the growth of pre-existing particles”. For this purpose, we carried out two groups of experiments with same initial conditions except the relative humidity (RH): one group was under less humid conditions (including dry conditions, RH < 20 %) and the other group was under high humid conditions (RH > 20 %). The number concentration of the NPF (N^{NPF}) was defined as the concentration difference between two groups of experiments. The number concentration of the particles related to the growth of pre-existing particles (N^{uptake}) was defined as the concentration under high humid conditions from which the concentration of the seed particles was subtracted. The value of y^{NPF} was determined by $N^{NPF}/(N^{NPF} + N^{uptake})$. In this study, isoprene ozonolysis was tested with this method. The influence of the number concentration and acidity of pre-existing particles, temperature, relative humidity (RH), the presence of OH radical scavenger, and the concentration of the reactants on the NPF yield was investigated. The formation of new particles with the diameters of less than 30 nm was observed in the presence of seed particles whose mean diameter was ~90 nm. Strong dependence of the NPF yield on RH was obtained: i.e., the yield decreased substantially with the increase of RH. In addition, the yield of the NPF was sensitive to the number concentration of the pre-existing particles. The NPF was dominant when the number concentration of the pre-existing particles was less than 10^4 cm^{-3} in our experimental conditions. The yield was low when the concentrations of the reactants were low. The acidity of seed particles and temperature did not affect the yield of the NPF obviously. This methodology can be used for the prediction of NPF in real atmosphere where extremely low volatility organic compounds (ELVOCs) act as the main nucleation agents in real atmosphere. We thank Ms. Sumiko Komori for her technical support. This work was supported by Steel Foundation for Environmental Protection Technology (FY2018–FY2020).

Keywords: New particle formation, Nucleating agent, Isoprene ozonolysis, Criegee intermediates, Oligomeric hydroperoxide

