Investigation of Particle Formation from Methanesulfonic Acid and Amines via Laboratory Studies and ab Initio Calculations

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Particle nucleation from trace atmospheric vapors accounts for a large fraction of the number concentration of particles in air and up to half of global cloud condensation nuclei. Understanding particle formation from gaseous precursors is therefore critical for improving our ability to predict visibility reduction, health effects and climate forcing. Methanesulfonic acid and amines are frequently detected in new particles in the atmosphere, indicating that they are potentially important gaseous precursors. While it is well established that ammonia and amines enhance particle formation from sulfuric acid by orders of magnitude, particle formation and growth from methanesulfonic acid and amines has only recently been demonstrated in this laboratory. In order to further investigate this chemistry at much earlier stages than previously possible, a borosilicate glass fast flow reactor was developed. Particle distributions are measured using a scanning mobility particle sizer for particles down to 2.5 nm, and gaseous precursors are collected and analyzed by ultra performance liquid chromatography and ion chromatography. The relative effectiveness of particle formation from ammonia, methylamine, dimethylamine, and trimethylamine with methanesulfonic acid and the dependence on precursor concentrations and relative humidity will be reported. Quantum chemical calculations are performed to provide insights on intermediate clusters and particle formation mechanisms. The effect of organics on particle growth is currently under investigation. Our results suggest that nucleation of methanesulfonic acid and ammonia/amine can partially explain particle formation in the atmosphere.