Atmospheric Chemistry and Physics
An Interactive Open Access Journal of the European Geosciences Union

Atmos. Chem. Phys., 9, 1907-1928, 2009
www.atmos-chem-phys.net/9/1907/2009/

Secondary Organic Aerosol Formation from Acetylene (C_2H_2): seed effect on SOA yields due to organic photochemistry in the aerosol aqueous phase

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Abstract. The lightest Non Methane HydroCarbon (NMHC), i.e., acetylene (C_2H_2) is found to form secondary organic aerosol (SOA). Contrary to current belief, the number of carbon atoms, n, for a NMHC to act as SOA precursor is lowered to n=2 here. The OH-radical initiated oxidation of C_2H_2 forms glyoxal (CHOCHO) as the highest yield product, and >99% of the SOA from C_2H_2 is attributed to CHOCHO. SOA formation from C_2H_2 and CHOCHO was studied in a photochemical and a dark simulation chamber. Further, the experimental conditions were varied with respect to the chemical composition of the seed aerosols, mild acidification with sulphuric acid (SA, 3<pH<4), and relative humidity (10<RH<90%). The rate of SOA formation is found enhanced by several orders of magnitude in the photochemical system. The SOA yields (Y_{SOA}) ranged from 1% to 24% and did not correlate with the organic mass portion of the seed, but increased linearly with liquid water content (LWC) of the seed. For fixed LWC, Y_{SOA} varied by more than a factor of five. Water soluble organic carbon (WSOC) photochemistry in the liquid water associated with internally mixed inorganic/WSOC seed aerosols is found responsible for this seed effect. WSOC photochemistry enhances the SOA source from CHOCHO, while seeds containing amino acids (AA) and/or SA showed among the lowest of all Y_{SOA} values, and largely suppress the photochemical enhancement on the rate of CHOCHO uptake. Our results give first evidence for the importance of heterogeneous photochemistry of CHOCHO in SOA formation, and identify a potential bias in the currently available Y_{SOA} data for other SOA precursor NMHCs. We demonstrate that SOA formation via the aqueous phase is not limited to cloud droplets, but proceeds also in the absence of clouds, i.e., does not stop once a cloud droplet evaporates. Atmospheric models need to be expanded to include SOA formation from WSOC photochemistry of CHOCHO, and possibly other α-dicarbonyls, in aqueous aerosols.

Final Revised Paper (PDF, 583 KB) Discussion Paper (ACPD)

Citation: Volkamer, R., Ziemann, P. J., and Molina, M. J.: Secondary Organic Aerosol Formation from Acetylene (C_2H_2): seed effect on SOA yields due to organic photochemistry in the aerosol aqueous phase, Atmos. Chem.

Phys., 9, 1907-1928, 2009. Bibtex EndNote Reference Manager