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

Atmos. Chem. Phys., 5, 275-291, 2005
www.atmos-chem-phys.net/5/275/2005/

Density changes of aerosol particles as a result of chemical reaction

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Abstract. This paper introduces the capability to study simultaneously changes in the density, the chemical composition, the mobility diameter, the aerodynamic diameter, and the layer thickness of multi-layered aerosol particles as they are being altered by heterogeneous chemical reactions. A vaporization-condensation method is used to generate aerosol particles composed of oleic acid outer layers of 2 to 30nm on 101-nm polystyrene latex cores. The layer density is modified by reaction of oleic acid with ozone for variable exposure times. For increasing ozone exposure, the mobility diameter decreases while the vacuum aerodynamic diameter increases, which, for spherical particles, implies that particle density increases. The aerosol particles are confirmed as spherical based upon the small divergence of the particle beam in the aerosol mass spectrometer. The particle and layer densities are calculated by two independent methods, namely one based on the measured aerodynamic and mobility diameters and the other based on the measured mobility diameter and particle mass. The uncertainty estimates for density calculated by the second method are two to three times greater than those of the first method. Both methods indicate that the layer density increases from 0.89 to 1.12g·cm^{-3} with increasing ozone exposure. Aerosol mass spectrometry shows that, concomitant with the increase in the layer density, the oxygen content of the reacted layer increases. Even after all of the oleic acid has reacted, the layer density and the oxygen content continue to increase slowly with prolonged ozone exposure, a finding which indicates continued chemical reactions of the organic products either with ozone or with themselves. The results of this paper provide new insights into the complex changes occurring for atmospheric particles during the aging processes caused by gas-phase oxidants.

Final Revised Paper (PDF, 1103 KB) Discussion Paper (ACPD)

Citation: Katrib, Y., Martin, S. T., Rudich, Y., Davidovits, P., Jayne, J. T., and Worsnop, D. R.: Density changes of aerosol particles as a result of chemical reaction, Atmos. Chem. Phys., 5, 275-291, 2005. Bibtex EndNote Reference Manager