

## LUND UNIVERSITY

Processing of Soot by Controlled Sulphuric Acid and Water Condensation - Mass and Mobility Relationship and Morphology

Pagels, Joakim; Khalizov, Alexei K.; Emery, Mark; McMurry, Peter H.; Zhang, Renyi Y.

2007

Link to publication

Citation for published version (APA):

Pagels, J., Khalizov, A. K., Emery, M., McMurry, P. H., & Zhang, R. Y. (2007). *Processing of Soot by Controlled Sulphuric Acid and Water Condensation – Mass and Mobility Relationship and Morphology*. Abstract from European Aerosol Conference, 2007, Salzburg, Austria.

Total number of authors: 5

General rights

Unless other specific re-use rights are stated the following general rights apply:

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights. • Users may download and print one copy of any publication from the public portal for the purpose of private study

or research.

- You may not further distribute the material or use it for any profit-making activity or commercial gain
- · You may freely distribute the URL identifying the publication in the public portal

Read more about Creative commons licenses: https://creativecommons.org/licenses/

## Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

LUND UNIVERSITY

**PO Box 117** 221 00 Lund +46 46-222 00 00

## Processing of Soot by Controlled Sulfuric Acid and Water Condensation – Mass and Mobility Relationship and Morphology

J. Pagels<sup>1,2</sup>, A. Khalizov<sup>3</sup>, M. Emery<sup>1</sup>, P.H. McMurry<sup>1</sup> and R.Y. Zhang<sup>3</sup>

<sup>1</sup>Particle Technology Laboratory, Dept. of Mechanical Eng., 111 Church St. S.E. Minneapolis, MN 55455, USA. <sup>2</sup>Division of Aerosol Technology (EAT), Lund University, Lund, Sweden. <sup>3</sup>Department of Atmospheric Sciences, Texas A&M University, College Station, TX 77843, USA.

Keywords: Soot Agglomerates, Condensation, Sulfur Particles, Fractals, Urban Particles

Soot particles are ubiquitous in the atmosphere and are of interest in studies related to adverse effects on human health and climate forcing. An important property of soot is its structure - or morphology. The morphology and mass-mobility relationship of fresh soot, such as diesel exhaust has been studied previously (e.g. Park et al. 2003). However, processing of soot undergoing condensation, simulating ageing in the atmosphere, has received much less attention.

We investigated the influence on morphology and the mass-mobility relationship of airborne soot particles upon coating with sulphuric acid and water. The main components of the experimental set-up were: 1. A Santoro burner, using propane as fuel to generate soot; 2. A Differential Mobility Analyzer (DMA) for selecting particles with given mobility size; 3. An "aerosol conditioner," which simulates processing similar to that which may occur in the atmosphere; 4. Either a second DMA or an APM (Aerosol Particle Mass Analyzer) to measure the altered mobility size or mass, respectively. This information also enabled us to determine the effective density and fractal dimension of fresh and processed soot. In the aerosol conditioner sulfuric acid was condensed onto the soot particles as described by Zhang and Zhang (2005). A heater was used to evaporate condensed material. A few experiments involved high RH cycling (a humidifier to increase the RH to 90% and a drier to reduce the RH to 5% before measurement).

$$\rho_{eff} = \frac{6m}{d_B^3 \pi} \quad (1), \qquad m \propto d_B^{Df} \quad (2)$$

Typically the mass (*m*) increased and the mobility diameter ( $d_B$ ) decreased as sulphuric acid was condensed onto the particles. The combined effects lead to an increased effective density ( $\rho_{eff}$ ; Eq. 1) and fractal dimension (Df; Eq. 2). The influence on morphology depended strongly on the mass fraction of condensed material in the processed soot particles. Coating the particles with a low sulphuric acid mass fraction (~20%) resulted in a moderate influence on  $\rho_{eff}$  and Df. Results for a higher H<sub>2</sub>SO<sub>4</sub> mass fraction (~55%) are given in Figure 1. The fractal dimension increased from 2.11 to 2.54 upon coating with sulphuric acid. An additional high RH

cycling further increased *Df* to 2.80. For sizes below 100 nm, effective densities approached the estimated bulk density and dynamic shape factors approached 1, indicating a transformation from highly agglomerated to compact, nearly spherical particles.



Figure 1. Effective density of fresh and processed soot.

Increased  $\rho_{eff}$  and Df were also observed when sulphuric acid was condensed on agglomerates and then removed by heating, indicating restructuring of the soot core. Soot with a hydrophilic coating, but not fresh hydrophobic soot, experienced restructuring upon RH cycling.

The atmospheric implication is that fresh (hydrophobic) soot will remain agglomerated when exposed to high RH cycles at subsaturation or upon low amounts of condensation. However as more mass condenses a gradual compaction takes place, which leads to full compaction at a mass ratio  $(m_{processed}/m_{fresh})$  of 2-3. If the condensate is hygroscopic then a high RH cycle even at RH below 100% can significantly progress the compaction.

This research was supported by NSF Grant No. BES-0646507, the Swedish Research Council FORMAS, DOE - NIGEC, US EPA, and Robert A. Welch Foundation.

- Park K, Cao F, Kittelson DB and McMurry PH. *Env. Sci. & Techn.* 37: 577-583, 2003.
- Zhang D and Zhang RY. (2005) *Env. Sci. & Techn.* 39: 5722-5728, 2005.