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2014

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Citation for published version (APA):

Nordin, E., Eriksson, A., Nyström, R., Lindgren, R., Rissler, J., Boman, C., & Pagels, J. (2014). *Mixing state and mass mobility relationship of aerosol from small scale biomass combustion*. Abstract OP62-3. Abstract from International Aerosol Conference, 2014, Busan, Korea, Republic of.

Total number of authors:

7

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Mixing state and mass mobility relationship of aerosol from small scale biomass combustion

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Keywords: biomass, combustion, APM, mass-mobility

Health effects from biomass combustion aerosol are expected to be dependent on the chemical composition, shape and size of the particles. Bølling et al. (2009) identified three main classes of biomass combustion aerosol in a simplified model; organics, soot and inorganic ash. The aim of this study was to determine the mass mobility relationship, mixing state of biomass combustion aerosol and its connection to chemical composition.

Emissions from batch wise operation of a conventional wood stove (WS) were diluted and transferred to a chamber. In addition a modern pellet boiler (PB) was used, where the emissions were sampled directly from the dilution system. The concentrations of CO, O₂ and NO (table 1) were measured in the undiluted flue gases. A Differential Mobility Analyzer (DMA) – Aerosol Particle Mass analyzer (APM) setup was used for determining the mass mobility relationship of the aerosol in the chamber. An optional thermo-denuder placed between the DMA and APM, was used to determine the remaining mass fraction at 300°C. The aerosol was further characterized on-line by a SP-AMS and SMPS. Particles were collected on substrates and filters for TEM and OC/EC analysis.

Table 1. Combustion conditions (average)

| Appliance | Phase | CO | O ₂ | NO |
|-----------|------------|-------|----------------|-------|
| | | [ppm] | [%] | [ppm] |
| WS | Start-up | 6200 | 19.5 | 3 |
| | Flaming | 1100 | 10.7 | 57 |
| PB | Continuous | 200 | 8.2 | 83 |

Figure 1 shows the effective density (ρ_{eff}) of the aerosol from three phases of wood stove combustion and continuous (nominal) operation of the pellet boiler. The aerosols in the figure can be grouped into three types of particles according to their size dependent density. 1) Particles with an $\rho_{eff} \sim 1.9 \text{ g cm}^{-3}$, 2) particles with an $\rho_{eff} \sim 1.2 \text{ g cm}^{-3}$ and 3) particles with decreasing effective density with increasing particle size. The three types is interpreted as particles dominated by salt (bulk density for KCL $\sim 2 \text{ g cm}^{-3}$) (1), organic droplets (within range of typical organic aerosol density) (2) and soot

aggregates (similar to Park et al. (2003)) (3).

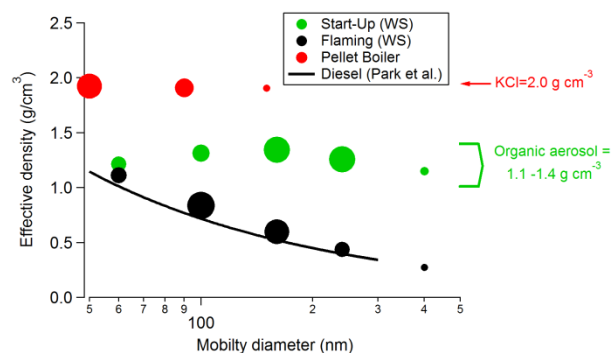


Figure 1. Effective density. The marker diameter is proportional to the relative number concentration at that size for each experiment.

Pure salt particles are only observed in emissions from the pellet boiler, which can be explained by the more favorable combustion conditions in that appliance. Organic particles were present during start-up presumably formed by wood pyrolysis products during cold combustion conditions. Soot aggregates were emitted during the flaming phase when the flame temperature is higher but with deficiency of air supply and/or bad mixing in the stove.

Acknowledgements

This work was supported by the Swedish research council FORMAS.

References

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