

# High-temperature tandem differential mobility analysis on the oxidation of wood combustion soot particles

H. Lamberg<sup>1</sup>, O. Sippula<sup>1</sup>, M. Ihalainen<sup>1</sup>, J. Tissari<sup>1</sup>, J. Joutsensaari<sup>2</sup>, A. Lähde<sup>1</sup>, J. Jokiniemi<sup>1</sup>

<sup>1</sup>Department of Environmental and Biological Sciences, University of Eastern Finland, Kuopio, FI-70211, Finland

<sup>2</sup>Department of Applied Physics, University of Eastern Finland, Kuopio, FI-70211, Finland

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Presenting author email: heikki.lamberg@uef.fi

Wood combustion emissions are of special importance due to their detrimental effects on the environment and human health. Oxidation of particles is especially important for decreasing the emissions in small-scale appliances because they often deteriorate the local air quality. To better understand the behaviour of wood combustion particles, their oxidation was studied using a high-temperature tandem differential mobility analyser system (Higgins et al. 2002) and a real-life combustion appliance.

Particles were generated using a pellet boiler, which was operated with low load mode to increase the proportion of soot within the particles (Lamberg et al. 2011). Although pellet boilers are not believed to cause major problems on the air quality, it offers a possibility for stable production of particulate matter and with selected setting it represented rather typical particle composition in small-scale appliances.

The aerosol was diluted using a porous tube diluter and an ejector diluter, and led to a sampling chamber that stabilized the small variation in the particle concentration generated by the combustion process. Sample was led from the chamber to a differential mobility analyser, which classified particles to a certain size class (40 nm, 100 nm or 200 nm). This was followed by a temperature-controlled laminar flow reactor. The oxygen concentration in the reactor was close to atmospheric concentration because of the sample dilution. Therefore temperature and residence times were the limiting factors in particle oxidation. Temperature inside the reactor tube was varied up to 1000 °C and the changes in the particle size were measured using a scanning electrical mobility analyser (SMPS, TSI Inc.). Particle samples were additionally collected for chemical analysis and electron-microscope analysis.

There was no considerable oxidation of the wood combustion particles below 500 °C for 40 nm and 200 nm particles. 100 nm particles on the other hand started to shrink considerably more already at 400 °C. The small change below these temperatures was most likely due to the evaporation of organic matter. In all particle sizes, the minimum particle sizes were reached at 750 °C. At 750 °C, both 100 nm and 200 nm particles reached GMD 28 nm, and 40 nm particles reached GMD 19 nm. Only very small changes in particle sizes were seen between 750 °C and 850 °C, but at 900 °C there was no particle mode left; soot particles in 100 nm size were oxidized at 750 °C and once temperatures reached 900 °C, also

inorganic particles were evaporated. Furthermore, the double mode in 600 °C shows (Figure 1) that there were two types of particles in the 100 nm size, for which the oxidation rate was different.

Chemical analyses of the PM<sub>1</sub> samples showed that about 50% of the PM<sub>1</sub> was composed of EC and about 10% of OC. The most abundant inorganic species were potassium, sodium, sulphate, chloride and nitrate. Their total share was about 25% of the total PM<sub>1</sub>.

Previous studies have been made using similar oxidation systems for analysing hydrocarbon flame soot particles and diesel particles. The oxidation of wood combustion particles in this study was found to oxidize in clearly lower temperatures compared with diesel and hydrocarbon flame particles. This difference originates from the different soot structures and different chemical compositions of the particles; wood combustion particles contain alkali metal and metal particles, which catalyse the oxidation reactions of soot particles.

These results bring new information on the wood combustion particle oxidation characteristics and can be utilized in designing of wood combustion appliances to enhance the soot particle oxidation.

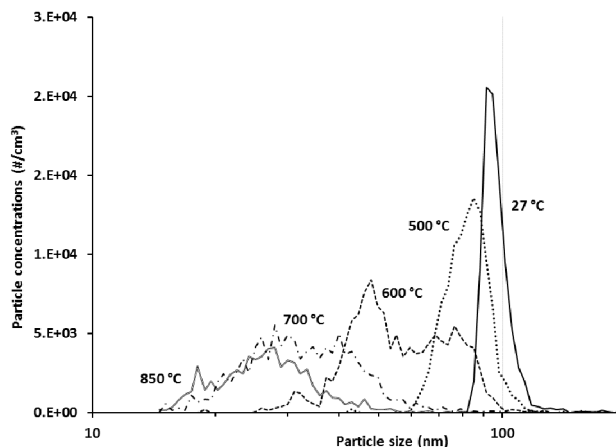


Figure 1. Particle number-size distributions using varying reactor temperatures with 100 nm particles.

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