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Physical and Chemical Characterization of Biomass Burning Aerosol

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Introduction

Combustion of biomass fuels for residential heating is considered to be a climate friendly option and is increasing globally. However, this implies potentially increased emissions of aerosol particles. $PM_{2.5}$, which is to a large extent comprised by combustion generated particle matter, co-varies with cardiovascular diseases (Bølling *et al.*, 2009). The composition of biomass burning aerosol can be divided into three main components, soot, alkali salts/ash and organic aerosol and is determined by combustion conditions like oxygen supply and temperature as well as the fuel. Soot and organic aerosol are a result of poor combustion conditions and are considered to be more harmful to human health than ash particles produced under optimal combustion conditions (Bølling *et al.*, 2009). A combustion cycle for example in a wood stove can emit episodes of poor combustion even when the overall combustion is relatively complete. The start-up phase is very sensitive to flash-over which results in air-starved conditions with emissions of soot and polycyclic hydrocarbons (PAHs). The aim of this paper is to study the change in aerosol properties due to different combustion conditions and phases using on-line aerosol measurement techniques.

Methods

The following combustion cases were studied; *i*) a conventional wood stove operated with high burn rate *ii*) a conventional wood stove operated with nominal burn rate, *iii*) a novel pellet reactor operating under air starved conditions, *iv*) a novel pellet reactor operating on optimal conditions, *v*) a modern pellet burner operated under optimal conditions. Mean flue gas and particle characteristics from the combustion cases are shown in table 1. The aerosol from the combustion appliances was diluted 1000-3000 times to concentrations relevant for ambient air before sampling.

Table 1: Particle characteristics and gas concentrations.

Case	CO (mg/MJ)	Total conc. (#*10^{13}/MJ)	Org (mg/MJ)
i	3020±2680	1.4±0.6	9.4
ii	2590±1030	1.3±0.6	8.6
iii	700±1390	1.1±0.3	6.5
iv	120±67	3.3±0.1	0.45
v	110±38	3.8±0.2	0.32

A high resolution aerosol mass spectrometer (HR-TOF-AMS, Aerodyne research Inc.) was used for size resolved composition of compounds vaporised at 600°C. A scanning mobility particle sizer (SMPS) was used for mobility size distributions (10-600 nm) and an aerosol particle mass analyser (APM) operated downstream a differential mobility analyser DMA) and an optional thermodenuder (300 °C) was used to determine the mass mobility relationship (effective density) and assess the size dependent organic mass fraction. Particles for TEM analysis were collected using an electrostatic precipitator. The AMS measures the size resolved chemical composition with very high time resolution and by using specific signatures in the mass spectra, compounds of particular interest like PAHs can be detected. For highly transient conditions like the start-up phase the time-resolution of the APM is not sufficient. Combining AMS and APM measurements will give novel and detailed information about the chemical composition, shape and morphology in all phases of the combustion cycle.

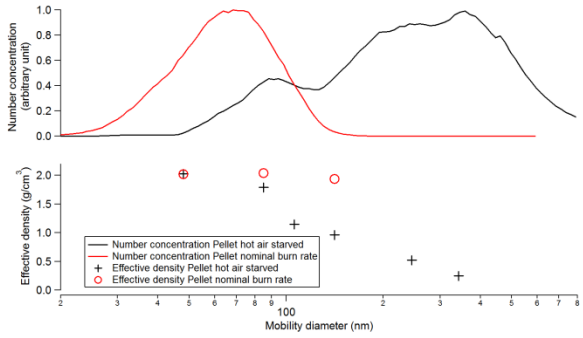

Figure 1: Average number concentration (upper panel) and effective density (lower panel) as a function of mobility diameter.

Conclusions

The effective density from DMA-APM measurements in case *iii* and *iv* (figure 1) gives an indication of the particle shape and composition. Salt aerosols have a relatively high effective density, which does not change with increasing mobility diameter, due to their spherical shape. Soot particles on the other hand have a lower effective density which is decreasing with increased size, due to their agglomerated shape.

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Bølling A. K. *et al.*, (2009) Particle & Fibre Toxicology, 6:29