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Characterisation of Particle Emissions from a Commercially Operated 1 MW Biomass Fired Boiler

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INTRODUCTION

Particulate emissions from a 1 MW biomass combustion unit was studied as part of a coordinated Swedish effort aiming to determine the possible negative effects of increased biomass combustion for power and heat production on the environment and human health. The investigation was performed on a moving grate combustor (1 MW) using moist fuel of forest residues (water content 30-55% by mass) for production of heat. The combustor was placed at Ingelstad, outside Växjö in southern Sweden. Detailed information about fly ash particle characteristics and ash transformation mechanisms are important in order to assess potential health hazards and to develop methods to reduce both ash deposition problems in the boiler and the fine particle emissions to the atmosphere.

METHODS

The aerosol particles were sampled before and after the multi-cyclone (figure 1). Measurements were carried out at different loads. The flue gases were diluted (1:10) and cooled to room temperature using particle-free dry compressed air. After the dilution the flue gas passed a cyclone with \(d_{50}\) at 10 \(\mu\)m. The size distributions of larger particles were studied with a time of flight instrument (TSI APS 3320). For chemical analysis, samples were taken either by a Dekati low-pressure cascade impactor or a stacked filter unit dividing the aerosol into a fine and a coarse fraction. The methods for chemical analyses include PIXE-analysis (Particle Induced X-ray emission) and analysis of major ions (Ion Chromatography). The
cooled gas stream was diluted further (1:10) before entering a DMA (TSI SMPS 3934) used for concurrent measurements of aerosol particle number size distributions.

RESULTS AND DISCUSSION

Typical particle size distributions measured after the multi-cyclone showed a CMD (Count Median Diameter) of 120 nm, GSD ~1.5, and number concentrations around $2 \times 10^7$ cm$^{-3}$. Mass weighted size distributions had a submicrometer peak around 200 nm. A coarse mode around 4 µm is found after the multi-cyclone. The magnitude of the coarse mode increased with increasing load. In Figure 2, size resolved sub-micrometer concentrations of selected trace elements are given as determined by PIXE. The transition metals Pb, Cd, Mn are chosen as they are all considered to be toxicologically active.

![Figure 1 Trace elements from PIXE-analysis](image1)

![Figure 2 Major elements from PIXE-analysis](image2)

PIXE-analyses also showed (Figure 3) that K, S, Cl and Zn were major elemental components of the sub-micrometer aerosol particle mass. When all sulphur was assumed to be in the form of sulphate, the elements quantified with PIXE ($Z > 12$) could account for around 60% of the particle gravimetric mass. Measurement of the particle hygroscopic properties (Rissler et al. 2001) taken during the same measurement campaign showed relative high growth factors of 1.6-1.9 at RH=90% (close to that of pure KCl and K$_2$SO$_4$). The hygroscopic behaviour was unimodal, suggesting that the processes of coagulation and condensation shapes the aerosol into an internal mixture, that is all particles of a given size have identical, or at least similar, chemical composition.

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REFERENCES