

Dynamic Changes of the Aerosol Composition and Concentration During Different Burning Phases of Wood Combustion

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Wood combustion is an important contributor to the ambient aerosol, especially during the wintertime. (Elsasser *et al.*, 2012). However, its contribution to the ambient pollution might be underestimated since emissions often have been approximated as a constant emission disregarding any compositional changes in the burning process.

Different on-line mass spectrometry-based methods with a high-time resolution were applied to investigate changes in the composition of the aerosol gas-phase and particle-phase during wood combustion. The experiments were carried out with a logwood boiler and a logwood stove at the Technology and Support Centre (TFZ) in Straubing, Germany. Different fuel types (spruce and beech) and burning conditions (normal, overloaded feed, oxygen-deficiency) were investigated. A Photo Ionisation (PI) Time-of-Flight Mass Spectrometer (ToF-MS) was applied for selective detection of aromatic organic compounds in the gas phase by Resonance Enhanced Multi Photon Ionisation (REMPI, Heger *et al.*, 1999). The aerosol particle phase of the non-refractory compounds was analysed by a High Resolution Time-of-Flight Aerosol Mass Spectrometer (HR-ToF-AMS, Aerodyne Research Inc., DeCarlo *et al.*, 2006). Together with FTIR measurement of the gas phase a comprehensive characterisation of the dynamic of wood combustion was achieved.

This dynamic could be described in four different burning phases, during which the aerosol compounds and concentration changed significantly. The novel approach of this study is to separate and categorize the phases of a whole batch based on observed chemical changes in the gas phase. For the first time positive matrix factorisation (PMF) was applied to separate different emission pattern from wood combustion.

The observation of the four different burning phases showed for example for the first phase (ignition phase), which was linked to the guaiacol signal, the highest concentrations of organic mass (figure 1). The following “harsh combustion phase”, which was linked to the naphthalene signal, showed a maximum of the relative amount of the “wood combustion marker” signal at mass-to charge-ratio (m/z) 60. Additionally, the inorganic compounds like sulphate and chloride had their maxima during this second phase and the following “stable combustion phase”. The start of the char burnout was indicated by an increase of the carbon monoxide concentration in the gas phase. The organic mass was the main contributor to the total non-refractory mass in all

the phases; however it decreased from 99% to 80% in the subsequent phases. This study demonstrates an overview of the impact of the dynamic phases of wood combustion on the composition and concentration of emitted aerosols. Additionally, it showed that burning conditions can significantly change the characteristics of emission. For example, an overloaded stove experiment showed a four-fold higher particle mass emission of non-refractory compounds (figure 1, below).

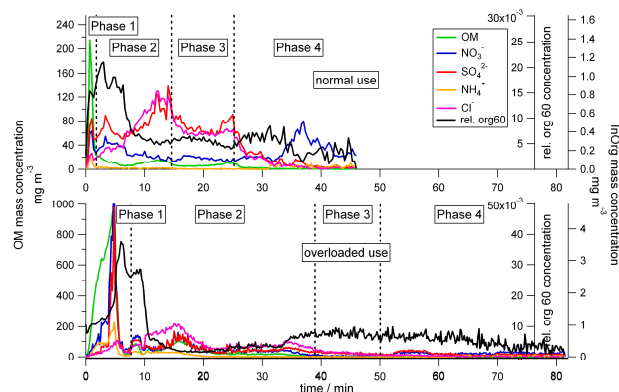


Figure 1. Variation with time of non-refractory aerosol components concentrations measured by AMS from a logwood stove experiment with beech: (top) wood under normal combustion conditions and (below) an overloaded stove experiment.

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Elsasser, M., Crippa, M., Orasche, J., DeCarlo, P.F., Oster, M., Pitz, M., Cyrus, J., Gustafson, T., Pettersson, J.B.C., Schnelle-Kreis, J., Prévôt, A.S.H. and Zimmermann, R. (2012) *Atmos. Chem. Phys.* **12**, 6113-6128.

Heger H. J., Zimmermann, R., Dorfner, R., Beckmann, M., Griebel, H., Kettrup, A., and Boesl, U. (1999) *Anal. Chem.* **71**, 46-57.

DeCarlo, P. F., Kimmel, J. R., Trimborn, A., Northway, M. J., Jayne, J. T., Aiken, A. C., Gonin, M., Fuhrer, K., Horvath, T., Docherty, K., Worsnop, D. R., and Jimenez, J. L. (2006) *Anal. Chem.* **78**, 8281–8289, 2006.