Residential wood combustion: time-resolved particle size distribution and morphological features

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Residential wood combustion is of increasing concern as it has been identified as a major source of atmospheric pollution, mainly in winter, either in rural (Puxbaum et al., 2007) or urban areas (Reche et al., 2012). Several studies have been carried out focusing on global emissions. However, another important aspect, poorly studied, is the analysis of time-resolved measurements. This continuous analysis can help understanding how these emissions evolve during the combustion process and how the different parameters are inter-related. Furthermore, it can be a useful tool to identify critical stages/intervals in the emission of particles, to contribute to the development of low emission combustion processes/technologies and, consequently, to reduce their impacts.

The size distribution of the aerosol emissions is crucial for evaluating the impacts on different aspects, such as health and climate. Another important parameter in the study of the aerosol is the morphology, as it provides knowledge of the individual composition, size and shape of the particles, a valuable information when particle formation processes, source apportionment studies and aerosol impacts are assessed.

The present study aims to characterise aerosol size distributions, number emission factors (EF) and morphological characteristics of particles emitted during the combustion of logs of three common Southern and mid-European woods (*Quercus pyrenaica* -oak-, *Populus nigra* -poplar-, and *Fagus sylvatica* -beech-) in two different combustion devices. The wood was cut into logs of 0.3 to 0.4 m in length with a total biomass burned during each combustion cycle of around 1.7 to 2.0 kg. The combustion of a batch of fuel lasted between 50 and 90 min.

Wood combustion experiments were carried out using two different combustion equipments: i) a stove operated manually in batch mode with handheld control of combustion air, and ii) a traditional Portuguese brick open fireplace operated manually in batch mode and with no control of combustion air. Both devices are equipped with a vertical exhaust duct (chimney) with 0.20 m internal diameter and 3.30 m height. Several parameters are continuously monitored during the combustion experiments: the weight of the fuel in the burning fixed bed at the grate, the temperature at several locations along the combustion system, the air flow rate entering in the combustion chamber (for the stove) or at the exit of the chimney (for the fireplace) (Calvo et al., 2014).

Aerosols in the combustion flue gas were continuously collected in a dilution tunnel (11 m length and 0.20 m internal diameter) located downstream of the chimney. Particulate sampling points were located at ~10 m downstream the dilution tunnel entering. Aerosol samples were taken from the dilution tunnel by means of a Venturi system, and redirected towards a second dilution tunnel of 1.13 m length and 0.07 m internal diameter. Two different instruments used this flue gas flow for particle sampling: i) an optical particle counter (PCASP-X), for the continuous monitoring of particle size distributions and ii) a Gent PM_{10} stacked filter unit sampler using polycarbonate filters (0.2 µm pore size) for later Scanning Electron Microscopy (SEM) analyses.

Important differences were observed in the aerosol size distributions and emission factors registered during the combustion process for the three studied wood species. The size of the primary particles comprising the aggregates emitted during the experiments ranged from 10 to 100 nm, with count median diameters of 35±7 nm, 38±11 nm, and 41±9 nm for poplar, beech and oak wood, respectively. Very variable mean aspect ratios were obtained for the aggregates in the analyzed samples, which values were closely related to the OC/EC ratios and optical properties, such as their light absorption wavelength dependency.

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