Primary and secondary emissions of pellets, logwood, and oil residential heating appliances: emissions factors, secondary particle formation and particle effective density

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Residential wood combustion is the main source of fine particulate matter ($PM_{2.5}$) in winter. This source also emits large quantities of organic species, covering a wide range of volatility, which through photo-oxidation processes in the atmosphere lead to the formation of secondary organic aerosols (SOA) significantly contributing to ambient air $PM_{2.5}$ concentrations. The potential and processes of SOA formation from these emissions are still poorly understood [1]. As the literature on the emissions from residential pellet appliances (stoves and boilers) is quite scarce, it is essential to improve the knowledge on their primary emissions, notably black carbon (BC), and their potential to form secondary particles. This work focused on the evaluation of the primary and secondary emissions from three modern stoves and three modern pellet boilers and their comparison to other fuel-fired residential appliances (a logwood boiler, a stove, and an oil boiler). The impacts of the output (nominal, reduced, and intermediate), as well as the composition of the pellets (softwood or hardwood), were also evaluated. After dilution (20-50 times), emissions were aged using a potential aerosol mass-oxidation flow reactor (PAM-OFR) with OH radical at ambient temperature and environmental relevant relative humidity (40-60%). The formation of secondary particles by nucleation processes was also investigated by filtering (HEPA filter) the entering emissions into the PAM-OFR. Primary and secondary emissions were measured on-line using a high resolution-time of flight-aerosol mass spectrometer (HR-ToF-AMS), a scanning mobility particle sizer (SMPS), a condensation particle counter (CPC), a multi-wavelength aethalometer, a proton transfer reaction time-of-flight mass spectrometer (PTR-ToF-MS) and gas analyzers (CO_2, O_2, CO, NOx, total VOCs) providing information on the particulate and gaseous chemical composition, particulate size distribution, and number concentration. Effective particle density at different aerosol size ranges has been investigated by combining a differential mobility analyzer (DMA) and a centrifugal particle mass analyzer (CPMA). Finally, samples (filters and adsorbents) have been manually collected at the emission and after dilution to carry out offline gravimetric and chemical analysis.

The measured primary (notably PM and BC) and secondary emissions will be compared and discussed in terms of wood-burning appliances, terms of use, and fuel burnt. The impact of the residential heating appliance operating conditions, as well as the photochemical aging, on particle effective density and morphology will be also presented.

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[1] Y. Olsen, J. K. Nøjgaard, H. R. Olesen, J. Brandt, T. Sigsgaard, S. C. Pryor, T. Ancelet, M. Viana, X. Querol, and O. Hertel, *Atmospheric Pollution Research,* **2020**, 11, 234-251.