Detailed Chemical Characterisation of organic aerosols emitted from Domestic Solid Fuel Burning

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The burning of solid fuels for home heating causes air quality problems worldwide. Wood or biomass is by far the most prominent type of solid fuel, however in Ireland, a combination of peat, coal and wood is typically used, especially in rural towns. In order to develop effective air pollution control strategies, information on the chemical composition and source strength of each of the solid fuels is required. In this study, we aim to use information on the detailed molecular composition of aerosols to establish a link between chemical speciation and different solid fuel types. Particles produced by burning commercially available coal, peat and wood in a modern stove were collected on quartz fibre filters and analysed. The results from these combustion experiments were then compared with those obtained from analysis of ambient PM2.5 collected in three small towns in Ireland.

Bulk characterization of combustion and ambient samples was performed using Direct Infusion UHR/MS (Orbitrap) coupled with mass spectral data evaluation methods, including Kendrick mass defect, Van Krevelen diagrams, carbon oxidation state and aromaticity equivalent. In total, over 20,000 species were identified with on average 55% corresponding to nitrogenated and sulfurated compounds (CHON, CHOS and CHONS) and 45% to oxygen-containing species (CHO). In addition, 55-95% of all species were aromatic in nature. Similar chemical distributions were observed in both combustion and ambient samples, indicating that many of these species originate from primary emissions, as opposed to being generated from in-situ chemical processing in the atmosphere. Up to 90% of the most intense chemical formulae in the ambient samples were also found in the fuel combustion samples, confirming that domestic solid fuel burning overwhelmingly influences the particle composition in the three sampling locations.

Detailed molecular characterization of the filters was also performed applying different analytical techniques, i.e. HPLC UHR/MS Orbitrap, High Performance Anion Exchange Chromatography with Pulsed Amperometry Detection (HPAEC-PAD); Curie-Point Pyrolysis Gas Chromatography Mass spectrometry (CPP-GC/MS) and High Performance Liquid Chromatography Electrospray Ionization Time of Flight Mass Spectrometry (HPLC/ESI-TOFMS). A range of alkanes, PAHs, hopanes, nitrophenols, methoxy- hydroxy-substituted aromatics and carbohydrates were quantified using standards and several other compounds, e.g. alkenes and fatty acids were identified.

The highest determined concentrations were obtained for alkanes, while PAHs such as benzo(a)pyrene and cyclopenta(cd)pyrene were also observed at high concentrations in both combustion and ambient samples. The results suggest that ambient PM2.5 in the three small towns contains significant quantities of toxic organic compounds produced from residential burning of solid fuels. The results also provide some new information on the contribution of the different fuel types – coal, peat and wood – to ambient PM2.5 in these locations, which will be useful for policymakers aiming to reduce air pollution from solid fuel burning.