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Gaseous and particulate composition of fresh and aged emissions of diesel, RME and CNG buses using Chemical Ionization Mass Spectrometry

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Urban air pollution is becoming a significant global problem, especially for large cities around the world. Traffic emissions contribute significantly to both elevated particle concentrations and to gaseous pollutants in cities. The latter also have the potential of forming more particulate mass via their photochemical oxidation in the atmosphere. The International Agency for Research on Cancer and the US EPA have characterised diesel exhausts as a likely human carcinogen that can also contribute to other health problems. In order to meet the challenges with increased transportation and enhanced greenhouse gas emissions, the European Union have decided on a 10% substitution of traditional fuels in the road transport sector by alternative fuels (e.g. biodiesel, CNG) before the year 2020. However, it is also important to study the influence of fuel switches on other primary pollutants as well as the potential to form secondary aerosol mass.

This work focuses on the characterisation of the chemical composition of the gas and the condensed phase of fresh bus emissions during acceleration, in order to mimic the exhaust plume that humans would inhale under realistic conditions. In addition, photochemical aging of the exhaust emissions was achieved by employing a Potential Aerosol Mass (PAM) flow reactor, allowing the characterization of the composition of the corresponding aged emissions. The PAM reactor uses UV lamps and high concentrations of oxidants (OH radicals and O_3) to oxidize the organic species present in the chamber. The oxidation that takes place within the reactor can be equivalent to up to one week of atmospheric oxidation. Preliminary tests showed that the oxidation employed in these measurements corresponded to a range from 4 to 8 days in the atmosphere.

During June and July 2015, a total of 29 buses, 5 diesel, 13 CNG and 11 RME (rapeseed methyl ester), were tested in two different locations with limited influence from other types of emissions and traffic. A Time-of-Flight Chemical Ionization Mass Spectrometer (ToF-CIMS) was employed to monitor the concentration of different organic species present in the fresh and aged emissions. This instrument is capable of identifying the molecular formulas of species in the gas phase. The FIGAERO inlet, also enabled the characterisation of the particle phase, as particles were simultaneously collected on a filter, from which they could then be thermally desorbed and detected. Acetate (negative) ionization was utilised to allow high sensitivity measurements of organic acids, aldehydes, ketones, diols and halogenated species.

The H_2O, O_3 and NO_x concentrations inside the PAM flow reactor were monitored, and an organic tracer for OH exposure was also continuously measured. The concentrations of dominant species in both fresh and aged gaseous and particulate bus emissions from the different fuel types will be presented as well as their emission factors, calculated from concurrent CO_2 measurements.