

Aerosol Mass Spectrometer measurements in a heavy fuel oil –fired heating station in Helsinki

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The particle emissions of energy production were investigated in a heavy fuel oil –fired heating station in Helsinki, Finland. The instrumentation included a dilution system and after that a versatile measurement device system with real-time instruments. Chemical properties, mass concentration, number- and mass size distribution, and volatility properties of emitted particles were studied. This paper focuses on the chemical characterization of sub-micron aerosol particles that were measured with an Aerodyne Soot Particle Aerosol Mass Spectrometer (SP-AMS). SP-AMS is a combination of two well-characterized instruments: Aerodyne high resolution time-of-flight aerosol mass spectrometer and single particle soot photometer. SP-AMS consists of particle sampling inlet, particle sizing chamber and particle composition detection section. The aerosol inlet samples sub-micron particles into the AMS through an aerodynamic lens forming a narrow particle beam. The beam is transmitted into the detection chamber, in which non-refractory components of aerosol are flash vaporized upon impact on hot surface under high vacuum. After that the components are ionized by electron impact ionization and the ions are detected by a mass spectrometer. In the SP-AMS, there is an additional intracavity Nd:YAG laser vaporizer (1064 nm) that enables to vaporize also refractory particles, specifically laser-light absorbing refractory black carbon particles and metals, that are not detected in a standard AMS. In this experiment, the heating station was operated with 30 MW (half power) and 47 MW (full power).

In the full power conditions, majority of the particle mass was composed of ions, mostly sulfate. 29% of the particle mass was made of trace elements whereas only 3.5 and 0.7% of the mass consisted of organics and black carbon, respectively. In the half power conditions, the total particle mass was little higher than in the full power conditions. With half power, elements comprised slightly lower and ions slightly higher portion of the particle mass than with full power. The contributions of organic and black carbon were almost the same with full and half power. Volatility characteristics of the particles emitted from the heavy fuel oil combustion in the half power conditions were determined using a thermodenuder (TD) before the SP-AMS. In addition to the room temperature, five temperature steps were used: 50, 100, 150, 200 and 250 °C. Mass and sulfate mass concentrations decreased as a function of the temperature. However, the concentration of organics did not change as the temperature was increased. This might indicate that there were heavier organic compounds in particles that are not volatile even in the temperature of 250 °C. Thus, the evaporation behavior of particles was based on the other components (e.g. sulfate) than organics.

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