Oxidative potential of logwood and pellet burning particles assessed by a novel profluorescent nitroxide probe


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As a source of renewable energy, residential biomass combustion is regaining importance. As such, it presents a significant source of aerosol particle emissions in many countries. However, only a limited number of studies evaluating the potential toxicological impact resulting from biomass burning exist (Naeher et al., 2007). In general, ambient particulate matter (PM) has been associated with various adverse health effects. Oxidative stress caused by particle-bound reactive oxygen species (ROS) and generation of ROS at the sites of deposition has been widely accepted as a hypothetical mechanism for PM-related injury. This study assesses the potential toxicological impact of particles produced by an automatic pellet boiler and a logwood oven, by using a novel profluorescent nitroxide probe BPEAnit. The probe is weakly fluorescent, but yields strong fluorescence emission upon radical trapping or redox activity. This makes it a powerful optical sensor for radicals and redox active compounds. Samples were collected by bubbling aerosol through an impinger containing 20 mL of 4µM BPEAnit solution, followed by fluorescence measurement. The combustion cycle consisted of cold start (startup and stable burning phase), restart (warm start) and bad burning (air inlet closed). During each of combustion phases, both test and HEPA filtered control samples were collected in impingers. PM was characterised using a Tapered Element Oscillating Microbalance (TEOM), a Scanning Mobility Particle Sizer (SMPS), a Diffusion Size Classifier (DiSC), a Fast Mobility Particle Sizer (FMPS) and a High Resolution Time-of-Flight Aerosol Mass Spectrometer (HR-ToF-AMS). The aerosol sample was delivered to the instruments and impingers via a dual stage heated (150°C) ejector dilution system. Based on the difference of fluorescence signal between test and control sample, the amount of ROS for each phase was calculated and normalized to the PM mass measured by the TEOM.

Figure 1 shows the calculated ROS concentration for four distinctive phases of logwood burning. Cold start burning resulted in a much higher amount of reactive species per unit of PM mass than warm start burning. In addition, sampling of logwood burning emissions after passing through a thermodenuder at either 150°C or 250°C did not result in a significant increase of fluorescence signal. This clearly indicates the importance of organics in PM-related toxicity. Particle emissions from the pellet boiler, although of similar mass concentration, were not observed to lead to an increased fluorescence signal during any of the combustion phases. This indicates a lower toxicological potential for particulate emissions from pellet boilers as opposed to logwood burning.

The obtained values for logwood burning emissions are relatively similar to diesel exhaust particles, but 10 – 50 times higher than sidestream cigarette smoke.

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