Light absorbing carbonaceous particulates from biomass burning: dependence on combustion conditions and photochemical processing

J. Martinsson[1], A. C. Eriksson[1], I. Elbæk Nielsen[2], V. Berg Malmborg[3], E. Z. Nordin[3], B. Svenningsson[1], E. Ahlberg[1], R. Lindgren[4], R. Nyström[4], E. Swietlicki[3], C. Boman[4], J. H. Pagels[3]

[1]Division of Nuclear Physics, Lund University, Lund, Box 118, SE-22100, Lund, Sweden
[2]Department of Environmental Science, Aarhus University, Roskilde, 4000, Roskilde, Denmark
[3]Ergonomics and Aerosol Technology, Lund University, Box 118, SE-22100, Lund, Sweden
[4]Thermochemical Energy Conversion Laboratory, Umeå University, Umeå, SE-90187, Umeå, Sweden
Keywords: Brown carbon, Burn phases, Biomass combustion, Wood stove
Presenting author email: johan.martinsson@nuclear.lu.se

The carbonaceous fraction of the ambient aerosol has a considerable effect on earth's radiative balance by absorbing and scattering incoming solar radiation. Organic carbon (OC) has a net cooling effect on the climate. However it has been shown that some OC can be highly light absorbing in the near UV-range (Kirchstetter et al. 2004). This fraction is often referred to as brown carbon (BrC).

Residential wood combustion (RWC) is a major source of BrC. However, there is poor knowledge about the relationship between combustion conditions and BrC emissions. Here we studied the optical properties and chemical composition of RWC emissions during different combustion conditions.

Logs of birch were combusted in a conventional wood stove. The diluted aerosol from different phases of the burn cycle was injected into a steel chamber and then analyzed with an Aethalometer. By assuming an absorption Ångström exponent (AAE) of 1.0 for black carbon (BC) we quantified the BrC emissions according to Sandradewi *et al.* (2008). Based on this approach we separate the total light absorbing carbon (LAC) into BC and BrC.

The composition of organic coatings and soot cores were investigated with a soot particle aerosol mass spectrometer (SP-AMS). The effects of intense photochemical processing (cumulative OH radical exposure of $3 \cdot 10^8$ $cm^{-3}h$) on composition and optical properties were investigated by means of a potential aerosol mass reactor (PAM).

The *fuel addition phase* is the period shortly after adding fuel to a bed of ember, *intermediate phase* represents combustion when the logs are fully covered with flames. The *burn out phase* started when the oxygen concentration had increased to 14%. The stove was operated in two modes, i.e. nominal (NB) and high (HB) burn rate. During HB, the conditions were more intense and partly air-starved resulting from dryer fuel and larger batches.

The AAE (370-660 nm) was significantly higher (≈2.5) in the fuel addition compared to other phases (≈1.0) (Figure 1). Consequently, the BrC fraction of LAC is highly dependent on burn phases. During the *fuel addition phase* a considerable fraction (35-75 %) of the total absorption is due to BrC. During *intermediate* and *burn out phases*, BC dominates the total light absorption (85-95 %).

Organic aerosol concentrations increased by a factor of 1-10 during processing in the PAM, dependent on combustion conditions. However, no significant difference in AAE was observed between fresh vs. photochemical processed aerosol (Figure 1). This suggests that secondary organic aerosol formed after processing at a high cumulative OH exposure shows very low, if any absorption.

Emission factors of BrC, BC and PAHs were higher for HB than NB. Thus, excessive burn rates should be avoided in RWC stoves.

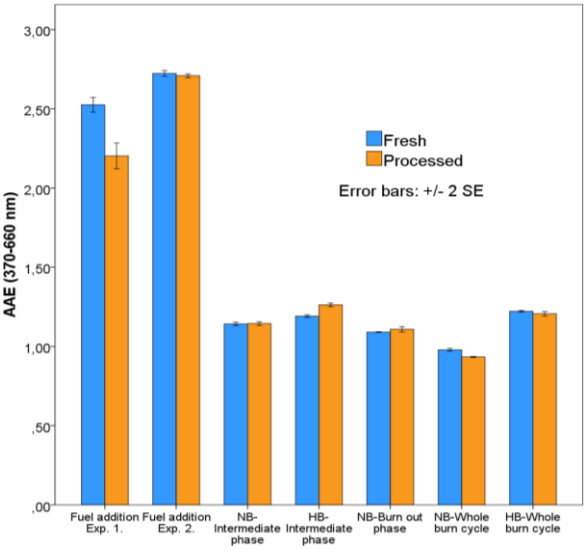

Figure 1. AAE for different burn phases and comparison of fresh vs. photochemical processed aerosol.

This research was founded by the Swedish Research Councils FORMAS and VR.

Kirchstetter, T. W., & Novakov, T. (2004). *J. Geophys. Res*, 109, D21208.

Sandradewi, J., Prévôt, A. S. H., et al. (2008). *Environ. Sci. Technol*, 42, 3316-3323.