Toxicity assessment of wood combustion emissions from different burning and aged conditions by using a reactive oxygen species (ROS) analyzer

J. Zhou[1], E. A. Bruns[1], P. Zotter[2], G. Stefenelli[1], D. Bhattu[1], J. Slowik[1], U. Baltensperger[1], A. Prévôt[1], T. Nussbaumer[2], I. El-Haddad[1], J. Dommen[1]

[1]Laboratory of Atmospheric Chemistry (LAC), Paul Scherrer Institute (PSI), CH-5232 Villigen PSI

[2]Bioenergy Research Group, Lucerne University of Applied Sciences (LUAS), CH-6048 Horw

Email: jun.zhou@psi.ch

1 Introduction

- **Inhaled particulate matter does induce oxidative stress in the lung caused by reactive oxygen species (ROS) [1].**
- **ROS play an important role in human aging processes and a variety of human diseases [2].**
- **ROS investigation helps to optimize combustion processes and to derive recommendations for regulations of air pollution control.**

Figure 1: Introduction of the background

2 Experimental overview

ROS formation during ageing of wood burning emissions in different photochemical reactors was quantified by an on-line ROS analyzer using an aerosol collector coupled to a 2',7'-dichlorofluorescin (DCFH) based assay. Different burning conditions and burning phases were investigated.

a. Two aging tools

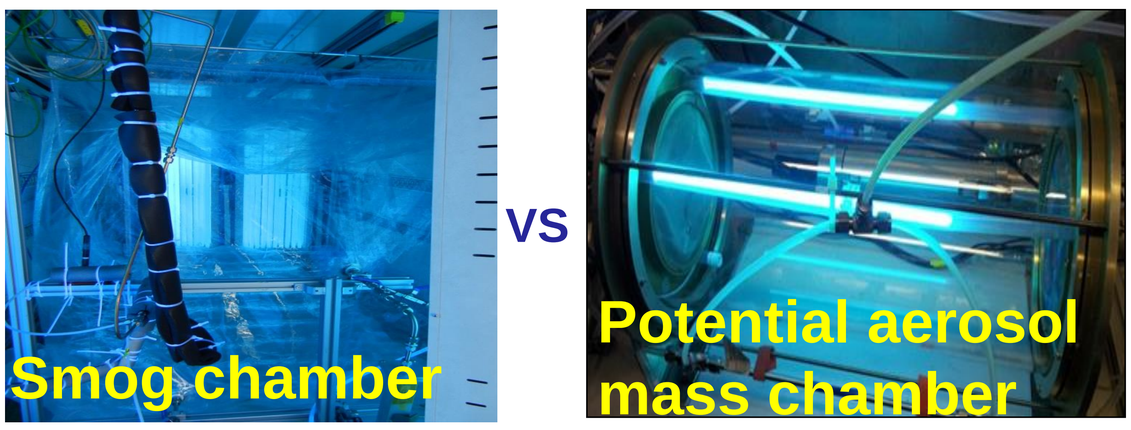

Figure 2: Wood burning emissions were aged in two different devices, a smog chamber and a flow tube (potential aerosol mass chamber).

b. Burning devices & conditions

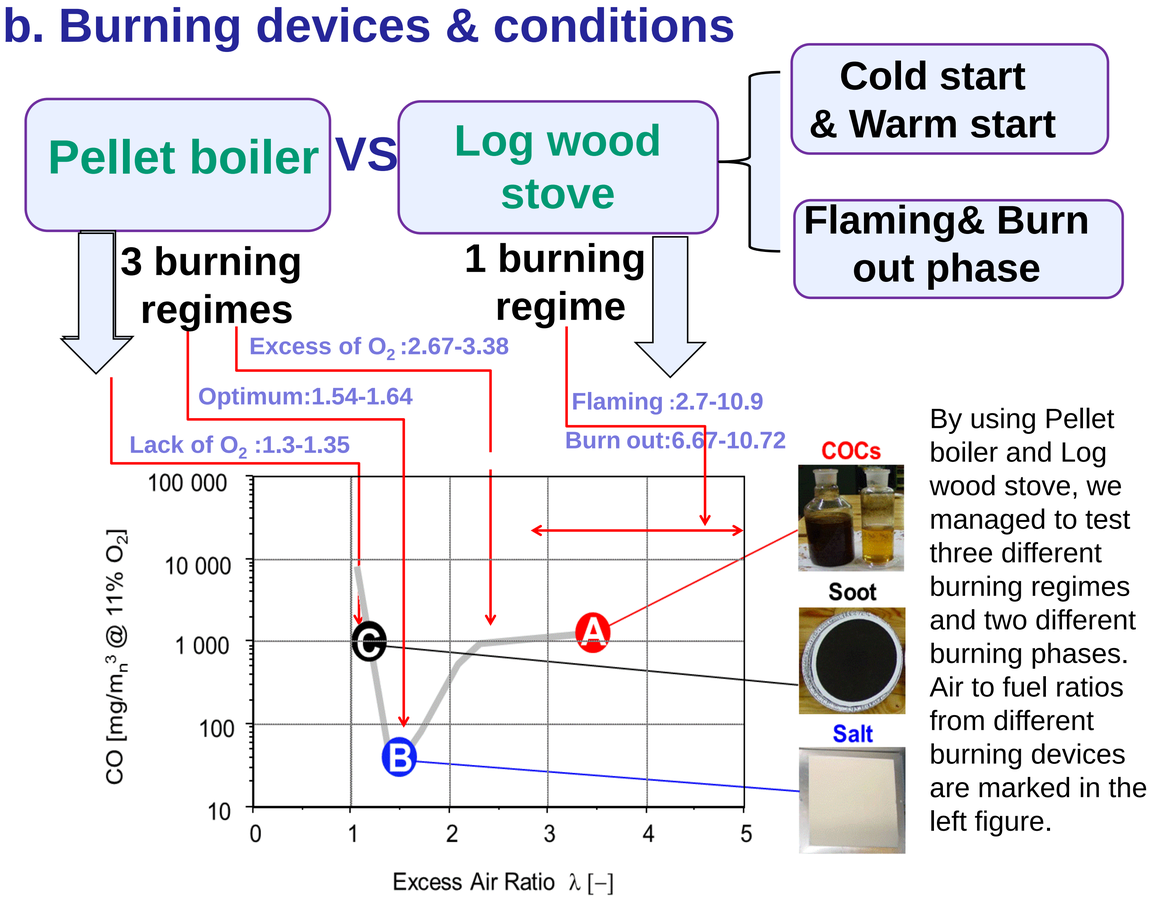

Figure 3: Two different burning devices including a pellet boiler and a log wood stove were tested. In the pellet boiler we tested 3 burning regimes corresponding to different excess air ratios. These different biomass combustion regimes produces different aerosols as seen in the lower part of the figure. By using a one stage log wood stove we tested the toxicity during cold start and warm start, as well as the different burning phases, i.e. flaming phase and burn out phase.

3 Results & Comparison

a. Comparison of different aging tools, burning devices and regimes

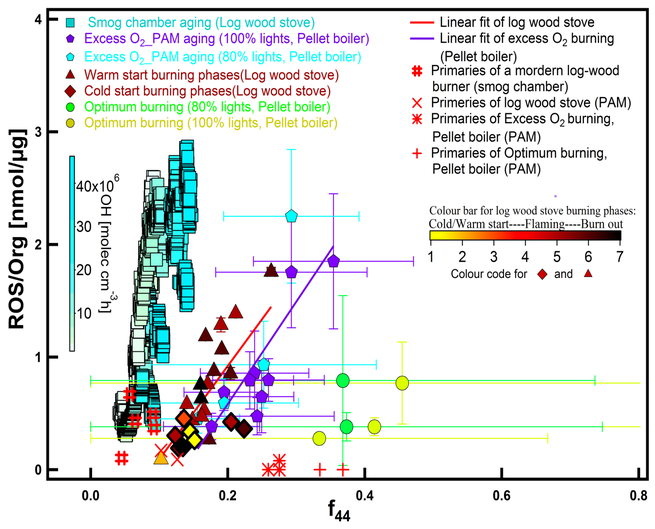

Figure 4: ROS formation from two aging processes (smog chamber and flow tube), two burning conditions in pellet boiler (optimum, with excess O_2) and different burning phases in log wood stove (cold start and warm start).

- After processing the flue gas in the Smog chamber/PAM reactor, the oxidation potential (OP) represented by ROS/Org increased for all SOA.
- ROS formation is related to the aerosol oxygenation degree (f_{44}). OP increased with f_{44} for both Smog chamber aging and PAM aging (in case of pellet boiler with excess O_2 and the wood stove).
- The oxidation potential of SOA from the pellet boiler under optimum conditions is only slightly enhanced despite of the high f44 and does not depend on the degree of oxygenation. Nevertheless, the uncertainties due to low SOA formation are higher. According to the lowest SOA emission factor (Bhattu et al., session 4, oral presentation), we may conclude that OP are lowest for the pellet boiler under optimum conditions.
- Different OH exposures (80% and 100% lights on) have not shown any significant impact on degree of oxygenation and ROS formation in PAM experiments.

b. Comparison of burning conditions

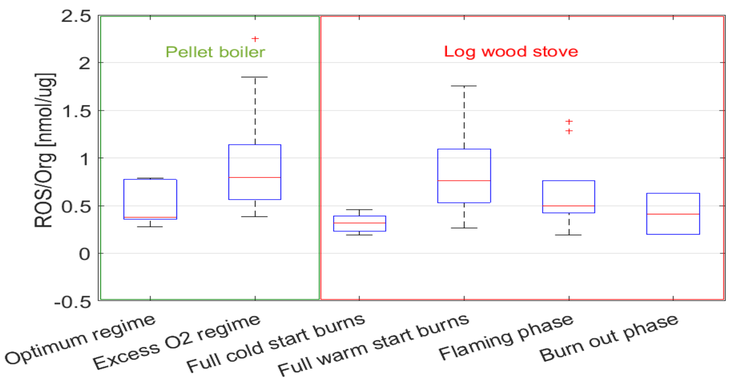

Figure 5: ROS/Org [nmol/µg] from different burning conditions plotted as box. Box: 75% (up) and 25% (down) percentile, red crosses: outliers of box value.

- In Pellet boiler, median value of ROS/Org for excess O_2 regime is higher than optimum regime.
- In Log wood stove, ROS/Org in flaming phase is higher compared to burn out phase.
- In cold start burns (including start, flaming, burn out), ROS/Org are lower compared to warm start burns.
- Pellet boiler Excess O_2 regime has similar ROS/Org level to log wood stove full warm start burns.

c. Toxicity comparison of different sources

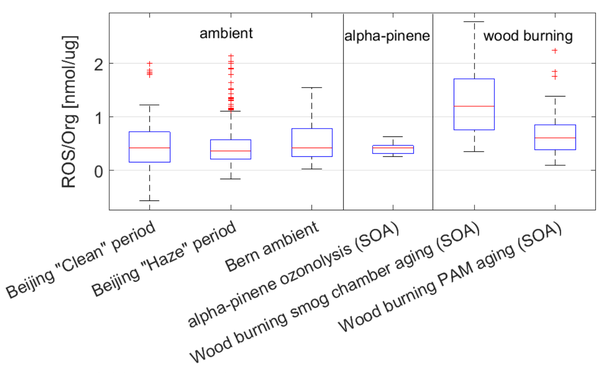

Figure 6: ROS/Org [nmol/µg] plotted as box-and-whiskers from different sources. Red line: the median value of all data. Box: 75% (up) and 25% (down) percentile, red crosses: outliers of box value.

- The median value of ROS/Org in photochemically produced SOA by smog chamber is higher than PAM.
- ROS/Org in photochemically produced SOA from wood burning emissions is higher than SOA produced from ozonolysis of α-pinene and ambient particles (including Beijing and Bern. For Beijing, we assume Org fraction is 40% of total mass according to Huang, et al., 2014 [4]).

4 Conclusions

1. Results from flow tubes and smog chambers show a positive correlation between ROS/Org and f_{44} in SOA, which indicates that aging substantially increases the ROS content of SOA. Smog chamber aging shows relatively lower aging degree but higher ROS fraction in Org when comparing with flow tube aging at the same aging degree.
2. Median ROS/Org of different burning devices and burning conditions doesn't show strong variations. Thus, the toxicity of flue gases from a manual wood stove and from a pellet boiler is mainly determined by the SOA formation potential, which is significantly higher for the wood stove compared to the pellet boiler due to significantly higher NMVOC acting as SOA precursors (Zotter et al., session 2, poster no. 26; Bhattu et al., session 4, oral presentation).
3. ROS/Org in photochemically produced SOA from wood burning emissions is slightly higher than from other investigated sources.

References

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Acknowledgements

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