LUND UNIVERSITY

Toxicological Responses to Ozone Aging of Aerosols from Small-scale Biomass Combustion

Nordin, Erik; Uski, O.; Nyström, R.; Jalava, P.; Genberg, Johan; Eriksson, Axel; Bergvall, C.; Westerholm, R.; Boman, C.; Jokiniemi, J.; Pagels, Joakim; Hirvonen, M-R.

Published in:
Proceedings of the European Aerosol Conference 2013

2013

Link to publication

Citation for published version (APA):
Nordin, E., Uski, O., Nyström, R., Jalava, P., Genberg, J., Eriksson, A., Bergvall, C., Westerholm, R., Boman, C., Jokiniemi, J., Pagels, J., & Hirvonen, M.-R. (2013). Toxicological Responses to Ozone Aging of Aerosols from Small-scale Biomass Combustion. *Proceedings of the European Aerosol Conference 2013*.

Total number of authors:
12

General rights
Unless other specific re-use rights are stated the following general rights apply:
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.
• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal

Read more about Creative commons licenses: https://creativecommons.org/licenses/

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

Download date: 19. May. 2025

Toxicological Responses to Ozone Aging of Aerosols from Small-scale Biomass Combustion

E. Z. Nordin[1], O. Uski[2], R. Nyström[3], P. Jalava[2], J. Genberg[4], A. C. Eriksson[4], C. Bergvall[5], R. Westerholm[5] C. Boman[3], J. Jokiniemi[6], J. Pagels[1], and M.-R. Hirvonen[2]

[1]Ergonomics and Aerosol Technology, Lund University, P.O. Box 118, SE-22100, Lund, Sweden
[2] National Institute for Health and Welfare, Kuopio, Finland
[3]Thermochemical Energy Technology Laboratory, Umeå University, SE-901 87, Umeå, Sweden
[4]Nuclear Physics, Lund University, P.O. Box 118, SE-22100, Lund, Sweden
[5]Dept. of Analytical Chemistry, Stockholm University, Svante Arrhenius väg 16, SE-10691 Stockholm, Sweden
[6] University of Eastern Finland, Department of Environmental Sciences,, Kuopio, Finland

Keywords: biomass combustion, aging, toxicology, PAHs,

Corresponding authors email: erik.nordin@design.lth.se

Small scale wood combustion for domestic heating and energy production is being regarded as a climate friendly alternative to fossil fuel combustion. Inefficient wood combustion emits elevated levels of aerosol particles and has therefore been recognized as a potential health threat, partly due to high content of polycyclic aromatic hydrocarbons (PAHs), of which several are rated as carcinogenic. When emitted to the ambient air the wood smoke aerosol is subjected to atmospheric aging, a process which physically and chemically transforms the aerosol, Kocbach Bølling et al (2009) states that more research is needed about health effects from aging of biomass combustion aerosol. The aim of this project was to investigate the toxicological response from fresh and aged biomass burning aerosol and link that to atmospheric transformation due to ozone aging and chemical composition of the aerosol.

A conventional wood stove was used in the study, operated in two modes, normal firing procedure at nominal load (NOM) and adjusted sooty procedure which gave a more incomplete combustion (denoted wood smoke, WS) (two experiments of each). To study the toxicological effects of aging a new method was developed, which allowed us to use the same batch of wood smoke aerosol for both studies of fresh and aged aerosol. The emissions were diluted and sampled to a 15.3 m^3 reaction chamber (Nyström et al., 2013). The emissions were characterized using online techniques (TEOM and SMPS), PUF + filters (gas and particulate PAHs), OC/EC filter sampling and gas monitors (NO_x and CO). For the toxicological studies filters were collected using a Dekati gravimetric impactor (DGI), the collected filters were also analyzed for PAHs, metals and ions. After characterization and filter sampling of the fresh aerosol about 1000 ppb of ozone was added and the aged aerosol was characterized in the same way as the fresh aerosol. By using aerosol from the same wood smoke batch, differences in chemical and physical characteristics between fresh and aged aerosol is avoided.

$PM_{1.0}$ from the DGI filters was used for the toxicological studies. The filters from each experimental situation were pooled together and the aerosol was extracted using an ultrasonic bath and methanol. The toxicological analysis was performed on mouse RAW264.7 macrophages using four different doses (15, 50, 150 and 300 mg ml^{-1}) and blank exposure and consisted of cell cycle analysis and cell viability tests (flow cytometry total DNA content analysis), inflammatory markers (cytokine TNF-α and chemokine MIP-2) and genotoxicity (Comet Assay).

The chemical composition of the aerosol from the four experimental situations is shown in table 1. The relative content of K, Cl and SO_4 was about four times higher for the more efficient NOM mode than for the WS mode. Only a minor increase in relative OC content was detected when aging the aerosol from the WS mode, the OC content decreased in the NOM case. This indicates that the aging process does not cause significant condensation of organic material on the soot cores. The relative particulate PAHs content measured on the DGI filters decreased from 0.39 % to 0.18 % when the WS mode aerosol was aged, which is an indication that the ozone aging induces surface reactions.

Table 1, Chemical composition of fresh and aged aerosol.

Experimental situation	OC (%)	EC (%)	NO_3 (%)	Zn (%)	K+Cl+ SO_4 (%)
WS-fresh	49.3	47.4	0.7	0.2	2.1
WS-aged	52.4	41.8	3.1	0.2	1.3
NOM-fresh	14.8	73.6	0.8	0,7	8.2
NOM-aged	6.2	78.6	6.2	0,8	6.8

Fresh WS mode particles were significantly more cytotoxic than the particles from the NOM mode. Ozone aging increased the cytotoxicity for both combustion modes. Fresh WS mode particles caused increased inflammatory responses compared to fresh NOM mode particles. The inflammatory responses was increased when the cells was exposed to aged NOM mode particles, compared to fresh. This effect could not be seen for the WS mode aerosol. All aerosol samples induced genotoxic responses higher than the control level. Due to the low viability of the cells exposed to the highest dose of fresh and aged WS mode aerosol, the samples could not be analyzed for genotoxicity. Aged aerosol from the WS mode gave by far the greatest genotoxic response.

The newly developed method was successful and made it possible to investigate the toxicity of fresh and aged biomass combustion emissions from two combustion situations, as well as characterizing the aerosol. The toxicity of aerosol from biomass combustion is affected by the combustion conditions and atmospheric aging. Aging of aerosol from incomplete combustion increases the DNA damage response compared to fresh samples of aerosol from the same combustion batch.

References:
Kocbach Bølling A. et al., (2009) Part Fibre Toxicol, **6**, 29.
Nyström R. et al., (2013) Conference proceeding submitted to EAC
Acknowledgements: This work was supported by the ERA-NET project Biohealth through the Swedish Energy Agency and the Swedish research council FORMAS.