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Published in:
Proceedings of Indoor Air Conference

2008

Link to publication

Citation for published version (APA):

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Indoor Sources of Fine and Ultrafine Particles – Detailed Particle Characterisation in an Indoor Chamber Setting

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Keywords: Aerosols, Indoor Particle Sources, Indoor Air Chemistry, Incense, Candles

1 Introduction

Fine and ultrafine particles have been associated with pulmonary and cardiovascular disease. The properties of particles from indoor sources are poorly known. The aim of this work was to characterise emission levels, physical and chemical properties of airborne particles from indoor sources in a controlled chamber setting.

2 Materials/Methods

Fine and ultrafine particles were generated in an air-tight 21.6 m\(^3\) steel chamber with controlled ventilation rate and relative humidity. The sources were: 1. Reaction products formed when combining indoor ozone with organic vapors (such as terpenes) from air fresheners and fruits and 2. Combustion sources of incense, candles and environmental tobacco smoke (ETS). These have been identified to be major indoor sources in field measurements (e.g. Wierzbicka et al. 2008). The particle size distribution was determined with an Electrical Mobility Spectrometer (SMPS). A TEOM was used to determine mass based source strengths. Filter and impactor samples were analyzed for elements, major ions and Elemental and Organic Carbon (EC/OC). Particle morphology was studied using Transmission Electron Microscopy (TEM). Different particle types from each source were separated using Tandem DMA-methods, where particles of well-defined size were conditioned to known RH (20-95\%) or temperature (20-600\°C). These methods were also used to assess the vapour pressures and water solubility of particle constituents.

3 Results and Conclusions

Particle number concentrations were highest for burning a single candle in calm air (~1*10\(^8\) cm\(^\text{-3}\)), while the highest mass emissions were determined from incense, environmental tobacco smoke (ETS) and candles exposed to increased air flows. Particles from air fresheners combined with ozone, extinguished candles, incense and ETS were dominated by organic compounds (OC) volatile below 200\°C with low water solubility. Candle burning with an unsteady flame emitted solid highly agglomerated soot (EC) particles, while steady burning candles emitted water-soluble salt particles which grow in the respiratory tract resulting in decreased deposition probability (Löndahl et al. 2008).

Table. Summary of particle properties.

<table>
<thead>
<tr>
<th>Particle Source</th>
<th>Particle Size, nm</th>
<th>Major Constituent</th>
<th>Water-solubility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Freshener +O(_3)</td>
<td>10-80</td>
<td>OC</td>
<td>low</td>
</tr>
<tr>
<td>Peeling Tangerine +O(_3)</td>
<td>20-150</td>
<td>OC</td>
<td>low</td>
</tr>
<tr>
<td>Incense</td>
<td>50-200</td>
<td>OC</td>
<td>low</td>
</tr>
<tr>
<td>ETS</td>
<td>80-150</td>
<td>OC</td>
<td>low</td>
</tr>
<tr>
<td>Candles Steady burn</td>
<td>15-40</td>
<td>Salts</td>
<td>high</td>
</tr>
<tr>
<td>Candles Sooting</td>
<td>200-300</td>
<td>EC (soot)</td>
<td>low</td>
</tr>
<tr>
<td>Candles Smoulder</td>
<td>200-300</td>
<td>OC</td>
<td>low</td>
</tr>
</tbody>
</table>

*Particle size given as range of count median diameter.

The large differences in particle chemical composition and solubility may have important implications for health effects. The detailed composition of organic compounds needs to be further investigated. For example ETS and incense particles are rich in Poly Aromatic Hydrocarbons (well-known carcinogens). Several of the characterised particle sources are currently being used in controlled human exposure studies (Andersson et al. 2008).

Acknowledgements:
This project was supported by FORMAS.

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