

Indoor particle load caused by burning of different types of candles and incense

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Burning candles and incense emit considerable numbers of particles, including harmful substances like benzo(a)pyrene (Wallace, 2000). Most studies on this issue were conducted in small test chambers in laboratories (e. g. Lau *et al.*, 1997; Fine *et al.*, 1999), so there is still a lack of information on particle emission under true-to-life conditions.

In this study the increase of detectable particle load in an interior room by burning candles and incenses was investigated. Therefore, tea lights, paraffin candles and beeswax candles were lit up in a furnished and previously aerated interior room and extinguished after one hour of burning. Total particle number concentration was measured with a condensation particle counter and particle size distribution (diameter 0.3 – 10 μm) with an optical particle spectrometer. Particles were also collected on quartz filters and afterwards analysed by temperature-programmed pyrolysis mass spectroscopy. This procedure was repeated for incense sticks and incense cones, but duration of these experiments was adapted to individual combustion times of the sticks/cones.

Mean total particle number concentration during combustion was highest for the beeswax candle ($4.6 \cdot 10^5 \pm 2.0 \cdot 10^4 \text{ cm}^{-3}$), followed by tea light ($3 \cdot 10^5 \pm 8.4 \cdot 10^4 \text{ cm}^{-3}$) and paraffin candle ($2.3 \cdot 10^5 \pm 4.7 \cdot 10^4 \text{ cm}^{-3}$) (Figure 1A). Emission of larger particles (0.3 – 10 μm) for all candles increased sharply after extinguishing though the particle number concentration was lowest for the tea light (Figure 1B). Even though the mean total particle emissions of the incense sticks and cones were lower than for candles, they reached considerably high concentration maxima ($1 \cdot 10^6 \text{ cm}^{-3}$ and $5.8 \cdot 10^5 \text{ cm}^{-3}$) (Figure 2A). The incense stick emitted much more particles of larger sizes than the incense cone (Figure 2B). With $\text{PM}_{10}/\text{PM}_{1}$ ratios between 0.91 (incense stick) and 0.99 (incense cone and tea light) fine particles contributed most to total particle mass. For pyrolysis, a distinct m/z difference of 14 amu probably implies the stepwise release of CH_2 groups from organic compounds. The fraction of low-volatile compounds of the tea light was much lower than for all other combustion articles.

The investigations of this study showed that candles and incense differ considerably in their emission schemes. New aspects on indoor particle pollution and hazards to health caused by these popular decoration articles were explored.

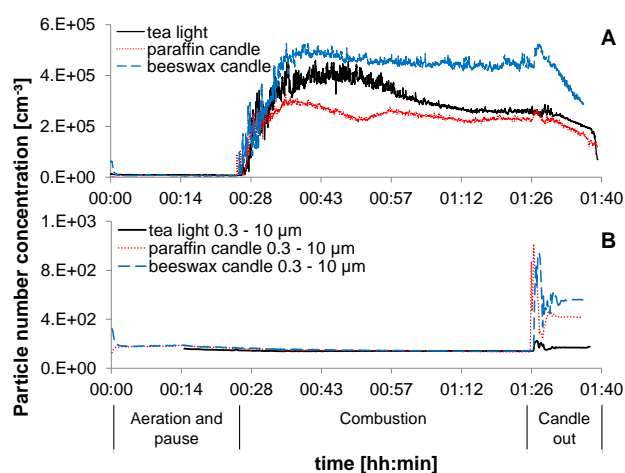


Figure 1: Total particle number concentration (A) and number concentration of particles 0.3 – 10 μm (B) during burning of tea light, paraffin and beeswax candle.

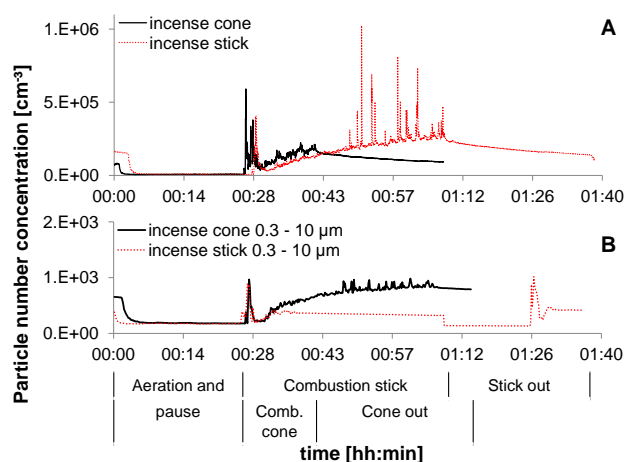


Figure 2: Total particle number concentration (A) and number concentration of particles 0.3 – 10 μm (B) during burning of incense cones and sticks.

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