

VOC and particle emissions from a household cleaning product

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Common household cleaning products (HHCP) may contain chemicals that affect human respiratory health (Zock *et al.* 2010). Both volatile organic compounds (VOCs) and aerosolized chemicals emitted from spray cleaning products, are of concern. The phase of the VOCs, i.e. gaseous versus aerosols, is important due to the different deposition mechanisms in the respiratory system. Thus, we followed the emissions of VOCs and the evolution of freshly nucleated aerosol particles from a common HHCP. In series of near- realistic user scenarios HHCP (20 to 40 g) was applied to a steel surface (1-2 m²) inside a walk-in exposure chamber (20.3 m³) that simulates indoor conditions with either low (10 ppb) or high ozone (45 ppb) levels. The air exchange rate was: $0.6 \pm 0.1 \text{ h}^{-1}$, temperature: $22 \pm 2 \text{ }^\circ\text{C}$, and relative humidity: $50 \pm 15 \%$. VOCs were measured by 1.) Sampling on Tenax TA adsorbent tubes and analyzed by thermal desorption-gas chromatography/mass spectrometry (TD-GC/MS) and 2.) Real time monitoring by atmospheric sampling Townsend discharge ionization (triple quad) mass spectrometry (ASTDI-MS) according to (Nøjgaard *et al.* 2007). Carbonyl compounds, such as formaldehyde, were sampled on 2,4-dinitro phenylhydrazine (DNPH) cartridges followed by liquid extraction and analysis by liquid chromatography with UV detection. Particles were measured by: 1.) Fast mobility particle sizer (FMPS), 2.) Electrical low pressure impactor (ELPI), 3.) Condensation particle counter (CPC), and 4.) Particle surface area monitor (NSAM).

The HHCP contains several terpenes (fragrances) with limonene as the most abundant. Limonene rapidly undergoes ozone-initiated reactions to produce a host of oxygenated products (Calogirou *et al.* 1999). These products are of concern, since they are suspected to adversely affect the indoor air quality; further, secondary organic aerosols (SOA) are formed, e.g. (Vartiainen *et al.* 2006).

Preliminary results

A maximum gas phase limonene concentration about 350 $\mu\text{g}/\text{m}^3$ (63 ppb) was reached within the first 30 min upon application of 40 g HHCP at low ozone conditions. At high ozone conditions, well-known limonene oxidation products such as 3-isopropenyl-6-oxo-heptanal (IPOH) and 6-methyl-5-heptene-2-one (6-MHO) were observed in relatively constant concentrations for the first 100 min, see Figure 1. Hereafter, they decreased together with the limonene concentration. Similar trends were observed in real-time by ASTDI-MS.

Elevated concentration of small particles between 6 and 10 nm was observed immediately after application of the HHCP. Within two minutes, the small particle mode peaked around 30 nm and the number concentration increased from 500 to $9 \times 10^5 \text{ #}/\text{cm}^3$. In the beginning of the condensational growth, the mean diameter of the particles was 5.6 nm. After 120 minutes, the particle mean diameter increased to 110 nm.

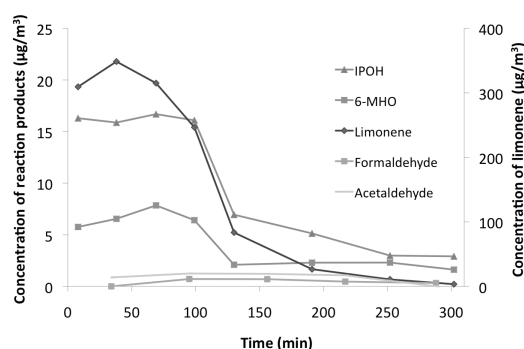


Figure 1. Ozone-initiated gas phase concentrations of limonene and some of its products measure by TD-GC/MS.

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Calogirou, A., Larsen, B.R., Kotzias, D. (1999) *Atmos. Environ.* **33**, 1423-1439.

Nøjgaard, J. K., Larsen, K., Wolkoff, P. (2007) *Int. J. Mass Spectrom.* **260**, 49-56.

Vartiainen, E., Kulmala, M., Ruuskanen, J., Taipale, R., Rinne, J., Vehkamäki, H. (2006) *Atmos. Environ.* **40**, 7882-7892.

Zock, J. P., Vizcaya, D., Le Moual, N. (2010) *Curr. Opin. Allergy and Clin. Immunol.* **10**, 114-120.