Application of Gas Phase Advanced Oxidation to Indoor Air

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Indoor air pollution is responsible for approximately 3.5 million premature deaths annually[1]. Volatile organic compounds (VOCs), among others, are common indoor air pollutants. Two gas-phase advanced oxidation (**GPAO**)[2] prototypes (Fig 1) were built to clean indoor air. The process consists of using ozone (O_3) and UV-C light to produce in situ radicals such as OH, to oxidize the pollutants. The oxidation products in turn form particles, which are removed by a particle filter. Any excess O_3 is removed using a catalyst[2]. The performance of this process in the prototypes was studied using two pollutants, α-pinene and tetrachloroethylene (PCE).

Prototype I

Fig 1. Schematic drawing of prototype. 1) Inlet fan, 2) O_3 generator, 3) UV-lamp, 4) Reaction chamber, 5) HEPA filter, 6) MnO_2 catalyst, 7) Clean air chamber, 8) Outlet fan. Arrow indicates air flow

- Dimensions 152.5 x 24 x 26 cm
- Volume 62.6 L
- Volumetric air flow 487 L/min
- Residence time 12 seconds

Test compound: α-Pinene

α-Pinene is an endocyclic alkene within the monoterpenes. It is well studied in atmospheric chemistry and one of the most common indoor VOC due to its application in multiple fragranced consumer products. α-Pinene is a sensory irritant and non-carcinogenic. When oxidized by OH and O_3, possible breakdown products are pinonaldehyde, picnic acid, pinoic acid, acetone, formaldehyde and secondary organic aerosols[3,4].

1) Characterization and modelling

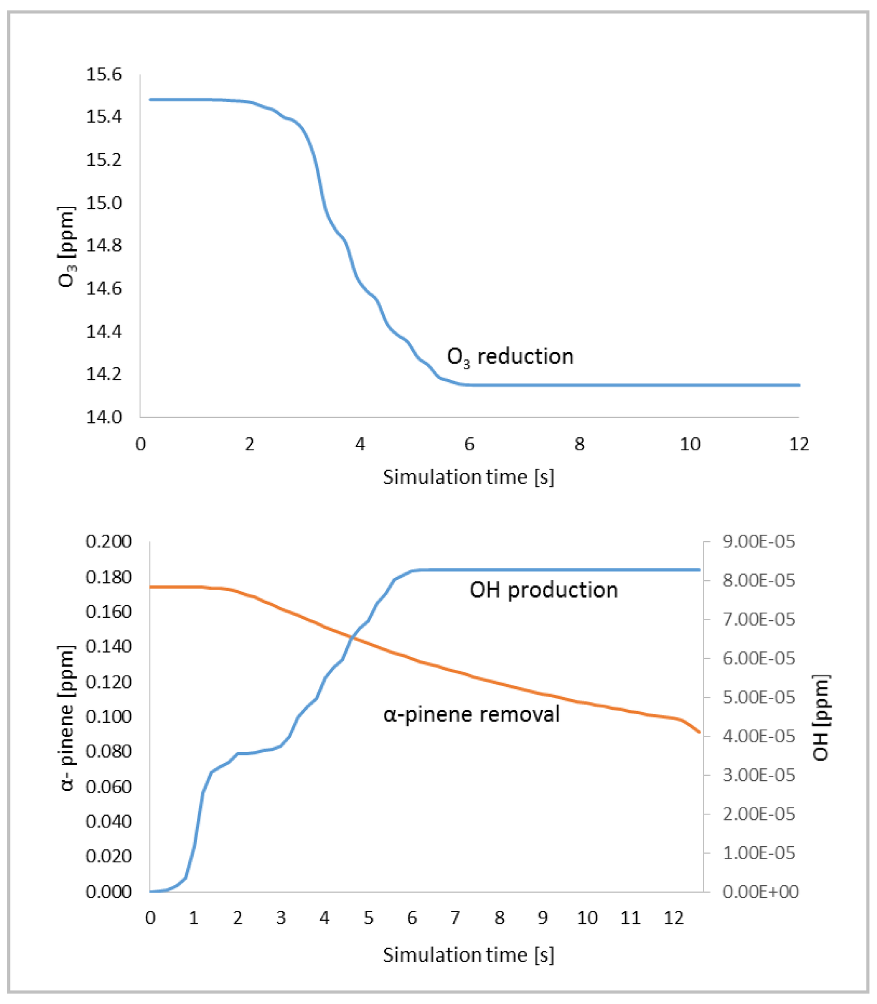


Fig 2. 12 s simulation of α-pinene oxidation by OH and O_3

A. The rate constant for O_3-photolysis was determined by measurement of O_3 concentrations before and after UV-light was turned on. No significant increase in photolysis rate was found for different O_3 concentrations (1.16-15.50 ppm). The photolysis rate constant for 15.50 ppm of O_3 was determined as 0.00486 s^{-1} and was used for further experiments and simulations.

B. A simulation of the reaction taking place in the reaction chamber was performed with Kintecus[5]. The chosen settings involved initial concentrations of 15.5 ppm of O_3 and 170 ppb of α-pinene. The simulation of one residence time (12 s) gave a **removal efficiency of 47.5% .**

2) Experimental α-pinene removal efficiency by PID

α-Pinene was continuously supplied to the reaction chamber by a bubbler. To explore the removal efficiency from the oxidation reactions with OH and O_3, PID (photo ionization detection) measurements were performed (Fig 3).

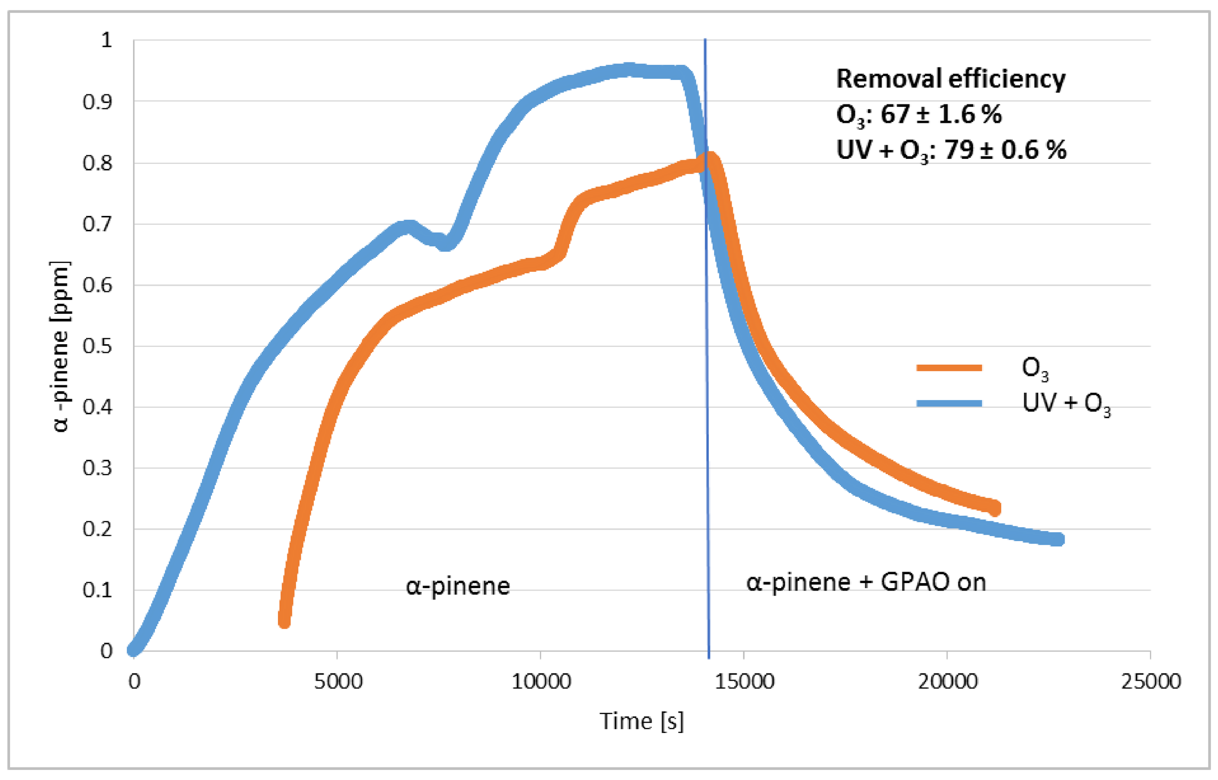
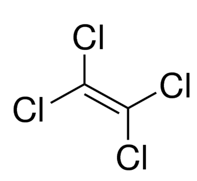


Fig 3. Removal of α-pinene by GPAO indoor prototype I

Prototype II

Fig 4. Prototype II at Innovation Garage, Skovlunde

Prototype II (Fig 4) is being tested at the Innovation Garage, a test site facility of the Region Hovedstaden, which is contaminated with chlorinated solvents deriving from former dry cleaning activities.



Tetrachloroethylene (PCE) is one of the chlorinated solvents detected. The chemical, which is considered possibly carcinogenic, enters the indoor environment through soil vapour intrusion[6].

Measurements are being conducted in a 21 m^3 large storage room by active sampling on Tenax tubes. Expected PCE breakdown compounds include Cl_2, CO_2 and HCl, as well as phosgene and trichloroacetyl chloride as by-products[7,8]. Results deriving from GC-MS analysis are expected soon.

A removal efficiency of α-pinene has been established at 79 ± 0.6 % and at 67 ± 1.6 % for UV + O_3, and O_3, respectively. In order to receive more accurate removal efficiencies of α-pinene and detect its oxidation products, an experimental set-up using Tenax tube sampling and subsequent GC-MS-analysis is needed for **prototype I**.

The experiments conducted with **prototype II** need to be analyzed for removal efficiencies of PCE and detection of possible breakdown products, as well as an assessment of their toxicity and potential health effects. Further, a comparison to values derived from model simulations will be of use.

In addition, particle size and distribution should be characterized for experiments done with **prototype I and II** by using a scanning mobility particle sizer.

References

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