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2009

Link to publication

Citation for published version (APA):

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Lund University Smog Chamber

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Keywords: Smog Chamber, SOA Formation, Ageing, Combustion Aerosols

Introduction

Particulate matter from anthropogenic combustion sources has been considered a health and environmental issue for a long time. Secondary aerosol formation from combustion processes is a subject that is not well known, because it involves a large number of complicated physical and chemical processes [1]. To be able to perform real-time measurements on ageing of combustion aerosols without contamination from the ambient air; a smog chamber has been installed inside the Lund University Aerosol Chamber [2].

Methods

The Lund University smog chamber is made of 5 mil (125 µm) DuPont FEP Teflon and has a total volume of 6 m³ (1.52 * 1.83 * 2.13 m³) in its rectangular parallelepiped shape. The smog chamber is manufactured by Welch fluorocarbon Inc. (US). It is equipped by a total of 12 (3*3 1/4" and 3*1 ¾") Kynar fittings manufactured by JACO Inc. (US), the fittings are placed on three of the vertical sides. The smog chamber is placed in a 21.4 m³ temperature controlled (22 ±1°C) steel chamber. [2]

A motor vehicle (diesel or gasoline) is running on idle for about 15 min. A Decati ejector dilutor is used to force the car exhausts into the system the ejector dilutes the exhausts about six times. The diluted exhaust is then inserted into the chamber via a preheated steel pipe with a flow of about 0.033 m³/min.

The exhaust is then further diluted with dilution air inside the Teflon chamber. The total dilution ratio in the Teflon chamber is typically 80 – 100 times, but can be chosen to fit the concentration level of a given car. The dilution air in the smog chamber is dry pressurized air coupled through a double set of activated carbon and Nano filters (Beko, De). The pressurized air is also used to ventilate the chamber before and after experiments.

After the exhaust injection the Teflon chamber was left for 30 minutes to allow mixing of the aerosol and to determine the particle properties before photo-oxidation. After the mixing the combustion exhausts are exposed to UV radiation from fluorescent tubes with a spectrum peaking at 350 nm and a total power of 1600 W.

The ageing experiments in the smog chamber are monitored by a Scanning Mobility Particle Sizer (SMPS) (built at the department), Aerosol Mass Spectrometer (AMS) (Aerodyne Research Inc, US), Tapered Element Oscillating Microbalance (TEOM) (Rupprech & Patashnick Co, US), Aerosol Particle Mass Analyzer (APM) (Kanomax, JPN) and several gas analyzers. The gas levels in the exhausts are measured by a TESTO 350 flue gas analyzer before and after the dilution ejector.

Figure 1. The measurement setup

To verify that the smog chamber is not contaminated with VOCs from previous experiments, a cleaning process was developed. 500 ppb O₃ is inserted into the chamber, the UV-lights are running in intervals of 30 minutes, with the AC system turned off, which also raises the temperature to about 40 °C. The cleaning process is running for at least 5 h. The chamber is ventilated with filtered air before and after the cleaning process.

Conclusions

The concept with the Teflon smog chamber has proven to be suitable for ageing experiments, where combustion aerosols are exposed to UV radiation. One problem has been that the Teflon easily becomes electrostatically charged, which enhances the particle deposition on the chamber walls. This leads to an underestimation of the particle number concentration the Teflon chamber. This is partly solved by using a deionizer, and can also be compensated by modeling the wall deposition.

Acknowledgements: This project is funded by The Swedish Research Council FORMAS.