Qualitative Characterization of Nanoparticle Emissions from Office Machines with Printing Function

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Introduction

This poster outlines some important aspects of the methodology for the characterization of particulate as well as gaseous emissions from office machines under controlled conditions. It also presents first results on chemical analysis of particles, emitted from laser printers.

Methodology

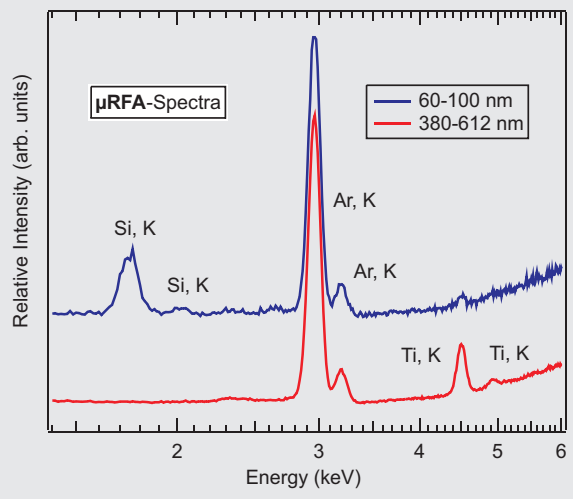
A 1 m^3 stainless-steel emission test chamber is used which is especially designed for the measurement of gaseous and particulate emissions. In order to determine emissions of volatile organic compounds in small concentrations down to the lower µg/m^3 range and to gain good reproducibility in particle spectroscopy the test chamber must also meet a number of requirements (BAM 2003):

- Temperature, relative humidity, air exchange rate and air flow velocity must be kept constant at specific values.
- Constant climate (23 ± 2 ºC, 50 ± 5 % relative humidity).
- Efficient air mixing with air flow between 0.1 and 0.3 $m \cdot s^{-1}$ and air exchange rate between 1 h^{-1} and 5 h^{-1}.
- Chamber walls of glass or polished high-grade stainless steel in order to minimize wall effects.
- Minimized use of sealing materials because it may contribute to gaseous emissions or adsorptions and desorption effects.
- Heat cleaning facility (up to 200 °C in order to tackle chamber memory effects).
- Clean air and water supply with low VOC and negligible particle content.

Instruments

A 13 stage (30 nm - 10 µm) low pressure cascade impactor (Dekati LPI-10) is used in order to take size resolved samples from the particles emitted. The impactor is operated at a rate of 10 liters per minute and polycarbonate foils are used as substrates.

Additional the emissions are size selected through a SMPS-System (TSI 3936) and sampled in a Nanometer Aerosol Sampler (TSI 3089) on TEM Grids or Al-foils.

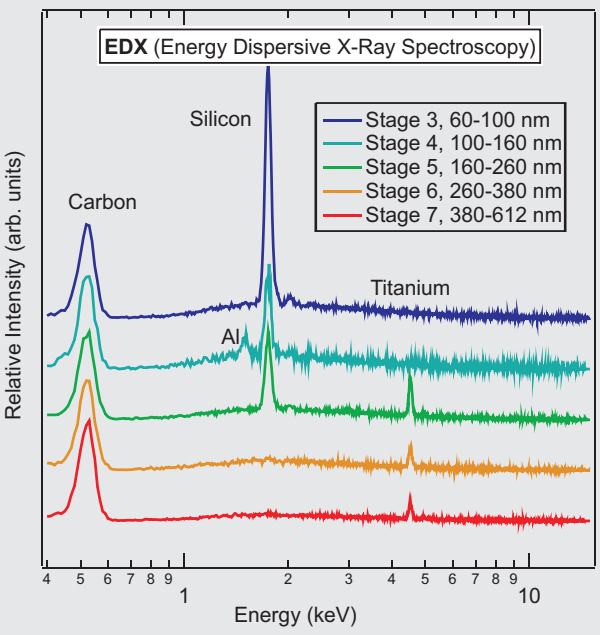


Particle samples are analyzed by three methods:

- ESEM (Environmental Scanning Electron Microscopy): Shape and size of particles.
- EDX (Energy Dispersive X-Ray Spectroscopy): Size resolved chemical composition.
- µRFA (Micro beam Roentgen Fluorescence Analysis): Size resolved chemical composition.

The figure above shows µRFA-spectra taken from sampled particles of stage 3 and stage 7 of the cascade impactor.

The figure below reveals EDX-spectra taken from sampled particles of stage 3 to stage 7.

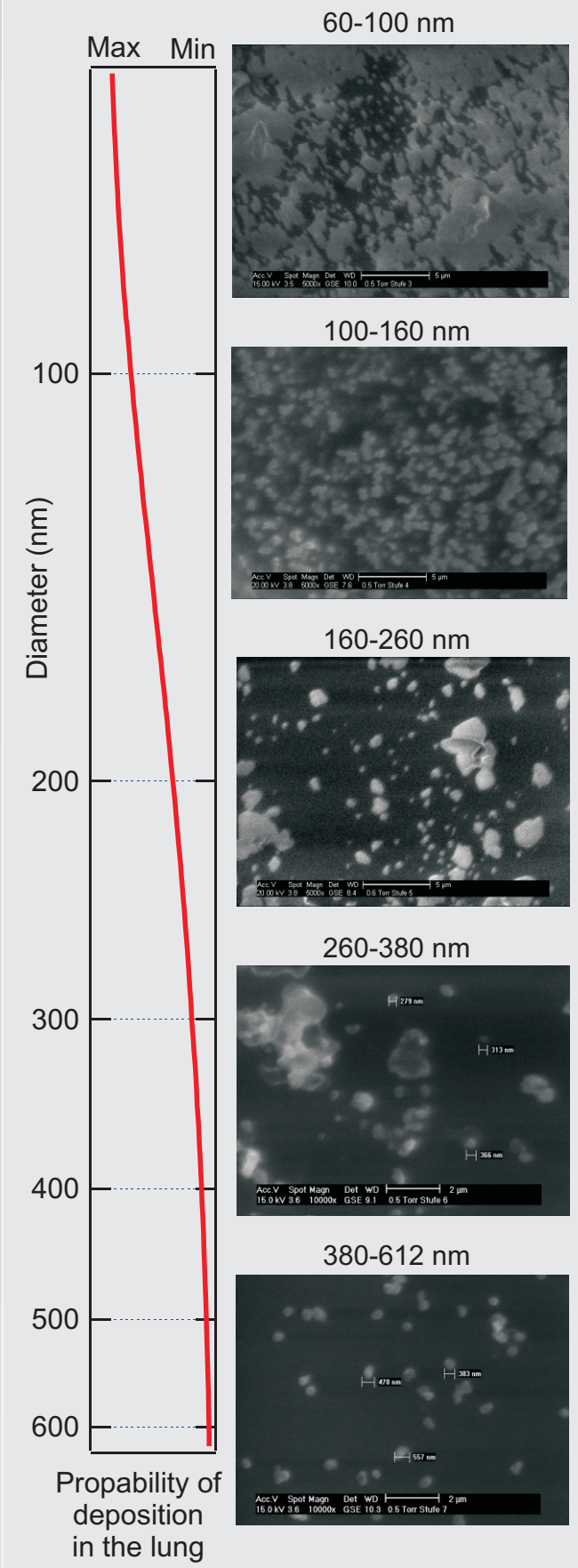


Results

The results of both spectroscopy methods applied are in concordance: There is a remarkable difference in the chemical composition of particles in different stages: Only Titanium is found in stages 6 and 7, while Si is missing. In stage 3, 4 and 5, however, Si is the dominant contribution while Ti is clearly not visible in stage 3 and 4. Carbon is visible in all spectra because this element is ubiquitary. The Argon peak in the µRFA-spectra is a contribution from the ambient air.
The particle number concentration maximum for the printer in this example is around 110 nm diameter. Thus, the number concentration maximum consists of small particles containing Si, while the mass maximum consists of bigger particles containing Ti.

ESEM

(Environmental Scanning Electron Microscopy)



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BAM (2003), Test method for the determination of emissions from hardcopy devices with respect to awarding the environmental label for office devices RAL-UZ 62, RAL-UZ 85 and RAL-UZ 114, BAM 06/2003, www.blauer-engel.de