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SIZE-RESOLVED ELEMENT DISTRIBUTION OF AIRBORNE (NANO)PARTICLES

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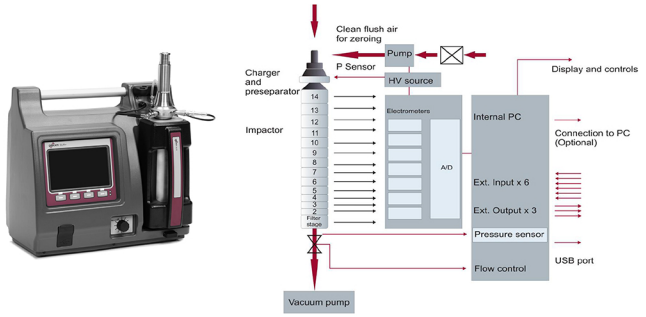
In urban areas outdoor air pollution is one of the major concerns possessing the single largest environmental health risk in Europe today [1]. One of the main air pollutants affecting air quality in cities is particulate matter (PM). Particulate matter is a complex mixture of very small particles and liquid droplets originating from various natural and anthropogenic sources. The size of these particles is directly linked to their potential for causing health problems, since ultrafine particles (< 100 nm) can deposit in all regions of our respiratory tract, while larger particles are retained in the upper parts of our respiratory system. Numerous studies have linked the exposure to PM to a variety of adverse health effects, such as increased respiratory symptoms, decreased lung function, asthma and even premature deaths in people with heart and lung disease. Since toxcity is related to particle size and source, it seems obvious to determine the chemical composition of airborne particles broken down by size classes to obtain size-resolved distribution patterns.
For this reason, we started to collect particulate matter in different urban environments using the electrical low pressure impactor ELPI®+. After microwave-assisted acid digestion and determination of element content using inductively coupled plasma mass spectrometry (ICPMS), we are able to determine distribution patterns for different elements in the particle size range from 17 nm to 10 µm. Our measurements should clarify if distribution patterns are source dependent, which would provide us with an excellent tool for source assignment of anthropogenic and geogenic mobilized elements and give new insights in the risks of airborne (nano)particles for human health.

Sample Collection

The results presented here, consider two sampling locations:

- A site vastly exposed to particles coming from traffic (intersection of Kotlářská street and Kounicova street (Brno, Czech Republic) that is considered a street canyon with a traffic intensity of approx. 35000 vehicles per day)
- An urban background location with low traffic intensity on the premises of the University of Graz (Graz, Austria)

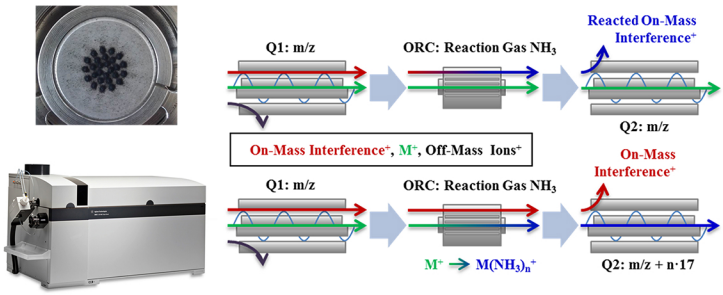
Airborne particles were collected on polycarbonate (PC) foils using an electrical low pressure impactor. The particles are separated on the basis of their size to 14 fractions ranging from 17 nm to 10 µm.



Electrical low pressure impactor; Operating principle of the ELPI®+. Source: www.dekati.com

Sample Preparation and Analysis

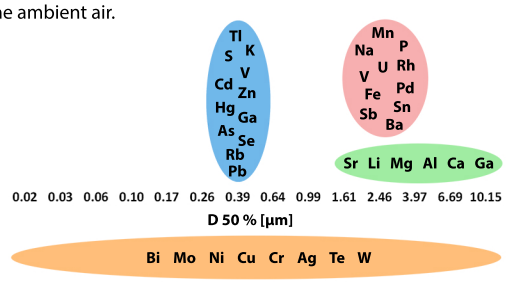
The PC foils with the particles on it were digested with 2 mL of subboiled nitric acid in a microwave heated autoclave (MLS GmbH UltraCLAVE, Germany) at 250°C for 60 min. The samples were then transferred into 50 mL polypropylene (PP) vessels and brought to a volume of 20 mL with ultrapure water (18 MΩ*cm). NIST SRM 1640a „Trace elements in natural water" and NIST SRM 1648a „Urban Particulate Matter" were used for quality control. Ge, In and Lu were added online as internal standards during the analysis with an 8800 triple quadrupole ICPMS (ICPQQQMS Agilent, Germany). For some elements the instrument was operated in „on mass" and „mass shift" mode with He, NH_3 and O_2 as collision and reaction gases.



Top left side - polycarbonate foil with PM on it; Bottom left side - 8800 triple quadrupole ICPMS; Right side - operating principle of the ICPQQQMS (Top: „On mass" detection; Bottom: Detection as analyte-cell-gas cluster „Mass Shift"). Source: www.agilent.com

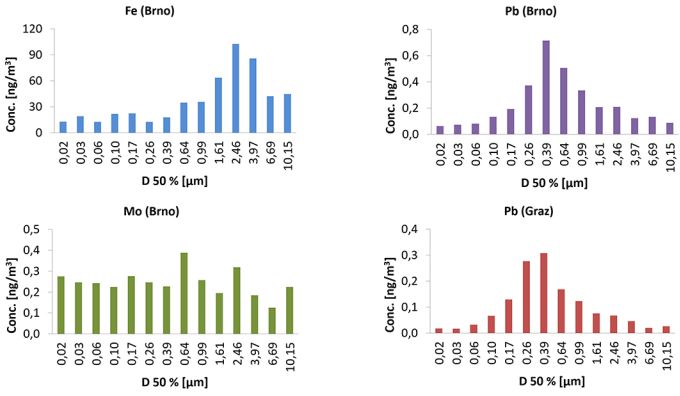
Results and Discussion

A total of 37 elements ranging from Li tu U were quantified in 14 different particle size fractions (from 17 nm to 10 µm). Total concentrations ranged from 530 ng/m³ for Fe to 0.4 pg/m³ for Rh for the sampling site in Brno. In Graz concentrations ranged from 422 ng/m³ for S to 0.6 pg/m³ for Pd. Determined total element concentrations were in general lower in Graz than in Brno, reflecting the sampling locations and the amount of particulate matter in the ambient air.



Distribution of analyzed elements classified according to the 14 size fractions from 17 nm to 10 µm.

Both measurements showed similar distribution patterns for the analyzed elements. According to our first results, elements can be divided into four major groups representing the fractions, in which the highest concentrations of each element can be found.



Size distributions of Fe, Mo and Pb in PM collected at sampling locations in Brno and/or Graz

As examples the element distributions of Fe, Mo and Pb (from Brno) are presented, also showing Pb for both sampling locations to indicate the higher concentrations at the sampling site in Brno in comparison to the one in Graz.

Our first results clearly show size-dependent element distributions, which can provide some new information about the origin of the particles. Health risk assessment should take this size dependency into account.

Ongoing work will be conducted by investigating public places with high PM concentrations as well as control sites without considerable impact of anthopogenic sources.

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References:
[1] European Environment Agency (2015): Air quality in Europe - 2015 report. Luxembourg (EEA report, No 5/2015).