X-ray fluorescence and absorption methods for identifying sources of urban aerosol pollution episodes

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European countries have made progress in reducing particulate air pollution in recent decades being concerned about their heath effect. Especially submicron particles can be detrimental due to their ability to reach alveolar region of the lung. Ultrafine particles (d < 100 nm) can even enter directly to the blood circulatory system. Although the number concentration and size distribution of particulates can be readily investigated by scanning mobility particle sizers, the chemical composition and speciation of particles are of high importance. The size distribution of elemental concentrations has a time variation dependent on sources and meteorological conditions. Both natural and anthropogenic sources can be strongly variable in time. Identifying unique pollution episodes is a difficult task hence the presence of emitted particles could be only a couple of hours.

Size fractionated urban aerosol samples were collected using a May-type cascade impactor onto 7 stages, covering a 70 nm – 9 μm diameter range. Sampling onto silicon wafers enables application of multiple non-destructive analytical methods like total-reflection X-ray fluorescence (TXRF), X-ray absorption near edge structure (XANES) or even scanning electron microscopy (SEM). Using a low-power, laboratory TXRF spectrometer, 0.1 ng/m^3 detection limit could be reached for transition metals at individual impactor stages from 4 m^3 of air sampled [1]. By combination of cascade impactor sampling and TXRF analysis, the particle size dependence of concentrations was obtained for both major (S, K, Ca, Fe) and trace elements (Cu, Zn, Br, Pb). Based on elemental size distribution determined by TXRF pollution episodes were identified. Samples with elevated Cu, Br concentrations were subjected to XANES measurements at the XRF beamline of Elettra (Trieste, Italy). The XANES spectra were analyzed through linear combination fitting of spectra from reference compounds.

With the combination of TXRF and XANES, Cu present in the samples of most episodes studied could be successfully linked to exhaust and non-exhaust type traffic related sources. For a unique short episode with co-existing elevated Cu and Br in the fine fraction, the ratio of organic/inorganic Br species could be determined. Both Cu and Br XANES results underlined that this pollution episode was caused by a local anthropogenic source.

This work was supported by the European Structural and Investment Funds jointly financed by the European Commission and the Hungarian Government under grant no. VEKOP-2.3.2-16-2016-00011 and the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme, through grant agreement 19ENV08 AEROMET II.

References

[1] J. Osán, E. Börcsök, O. Czömpöly, C. Dian, V. Groma, L. Stabile and S. Török, Spectrochim. Acta Part B 167 (2020) 105852.