

European Metrology
Programme for Innovation
and Research

Delivering Impact



A new device to improve European air quality

Air pollution has a profound impact on human health and the environment. Although many harmful airborne particles are strictly limited by legislation, there has been a lack of methods for chemical composition analysis of aerosols. Total Reflection X-ray Fluorescence, combined with fractioning using cascade impactors, could offer an effective solution but has lacked traceability and suitable calibrations.

Europe's National Measurement Institutes working together

The European Metrology Programme for Innovation and Research (EMPIR) has been developed as part of Horizon 2020, the EU Framework Programme for Research and Innovation. EMPIR funding is drawn from 28 participating EURAMET member states to support collaborative research between Measurement Institutes, academia and industry both within and outside Europe to address key metrology challenges and ensure that measurement science meets the future.

Challenge

According to [EEA estimates](#), 239,000 deaths in the EU in 2022 were attributable to fine particulate matter pollution (PM_{2.5}) at concentrations above the World Health Organisation's recommendation of 5 µg/m³. To mitigate the effects of air pollution on humans and the environment, regulatory bodies impose strict legal limits on airborne particles, covering a wide range of aerosols from numerous sources with a diverse range of properties. Although methods and standards for measuring the size distribution and mass concentration of these aerosols are well-established, chemical composition analysis has lagged behind. Measurements have relied on laborious methods which require aerosols to be transported from where they are captured to specific laboratories, leading to long delays between sampling and analysis as well as relatively high measurement uncertainties.

One method which can address these issues is Total Reflection X-ray Fluorescence (TXRF), which uses a fine beam of X-rays to analyse the chemical composition of particles deposited on a flat substrate. The beam is directed at the sample with a shallow angle and the x-ray fluorescence radiation is then analysed to rapidly determine which elements are present, even at levels as low as 1 part-per-billion. TXRF offers measurements with reduced background noise and improved sensitivity over similar methods. However, while TXRF spectrometers are commercially available, there has been a lack of traceable calibration standards and harmonised calibration procedures, leading to some unknown contributions to the measurement uncertainties and a lack of chemical SI traceability.

Solution

During the [AEROMET II](#) project a number of methods were used to create traceable calibration samples for TXRF analysis. In particular, these samples were designed to mimic the deposition patterns of cascade impactors, devices commonly used to fraction aerosol particles by size ranges. The methods tested included lithography techniques, vapor deposition and printing, and allowed the project to investigate the various requirements of the calibration samples, such as quality control, geometry of deposition and the suitability of different carrier materials. These samples were then used to demonstrate the effect of calibration reliability on accuracy and comparability in TXRF and to develop a preliminary method for calibrating benchtop TXRF instruments. This method was used to calibrate a TXRF spectrometer at the German project partner BAM, achieving an improved measurement uncertainty of 20 %.

Impact

Bruker Nano is a scientific instrument manufacturer based in Berlin, Germany, specialising in instruments for elemental analysis and materials characterisation. In particular, the company offers a range of high-sensitivity benchtop TXRF spectrometers, which can be used to perform composition analysis on aerosol samples.

As a partner in AEROMET II, Bruker Nano was motivated by the project's work to develop a new type of cascade impactor which produces deposition patterns optimised for benchtop TXRF spectrometers. As the device deposits directly onto carriers suitable for TXRF instruments, it offers a direct approach to sampling and analysis with a reduced amount of preparation. This allows for near-real time sampling which, in combination with the calibration samples developed during AEROMET II, is traceable to the SI. The use of a cascade impactor before analysis also allows users to identify which fraction elements are found in, helping to better identify, for example, the sources of toxic pollutants which could damage

human health or the environment.

The work of the AEROMET II project has helped to improve aerosol measurements through faster, simpler sampling and analysis. This will help manufacturers and bodies like air monitoring networks, and environmental researchers to better monitor key pollutants and ensure emissions stay within legal limits, protecting humans and the environment.

Developing metrology to improve air quality monitoring

Building on the work of previous EMPIR project [AEROMET](#), the AEROMET II project developed the metrology needed to improve air quality measurements and aerosol monitoring. The project created new aerosol measurement methods, plus reference materials for calibrating (optical) particle size spectrometers (OPSS), for chemical characterisation of aerosols and for automated pollen monitors, which were validated in four field campaigns. Benchtop Total Reflection X-ray Fluorescence spectrometers were calibrated, and a novel commercial cascade impactor was developed by the commercial project partner Bruker. A new OPSS facility was setup at NPL, and a particle size spectrometer calibration facility was extended at METAS for particles up to 20 µm, which was then used to calibrate instruments from MeteoSwiss. The project has also contributed to international standards, including CEN standards and technical specifications. The project's work has improved aerosol monitoring, helping to protect public health and the environment.



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