

Monitoring Air Quality

By LA-MC-ICP-MS

Introduction

Any measure of air quality in cities includes an analysis of fine solid particulates of diameter less than 10 microns (denoted PM10). At high concentrations these are associated with respiratory and cardiac ailments. The concentration of such particulates, trapped on the surface of a filter, is measured at various locations around London. Figure 1 (left) shows mean PM10 distribution in the UK during 2001. The highest concentrations occur around cities and centres of industry. The right hand map in Figure 1 shows one of the targets of the UK National Air Quality Strategy – a dramatic reduction in PM10 distribution by the year 2010. Figure 2 shows a photograph of a typical air quality monitoring station in London.

In addition to a simple measure of the density of particles in the air, it is also possible to perform more detailed isotopic analyses, to determine possible sources of lead in the particles.

Features of laser ablation (LA)-MC-ICP-MS:

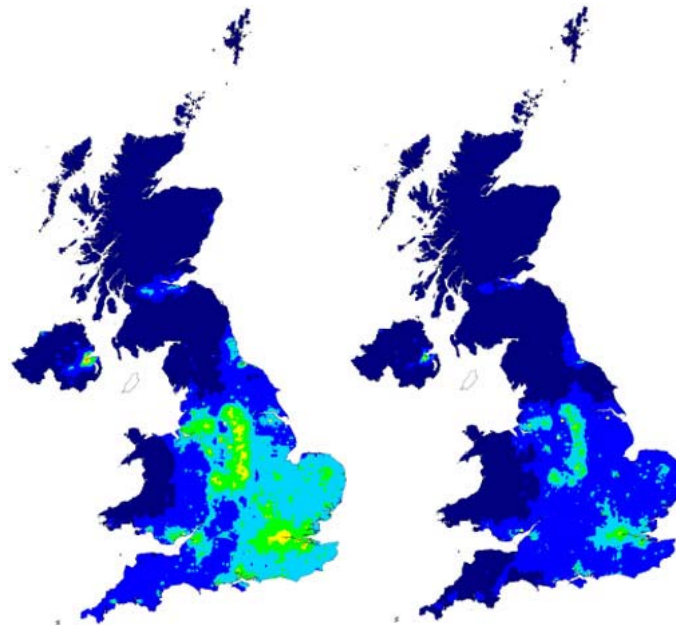
- Successful analysis of aerosol particles on filters
- Resolution of different components on the filter
- Higher throughput than solution analysis
- Overcomes selectivity of leaching methods

Analysis of Air Filters

Two sampling strategies were used which each have their own advantages. Acid leaching of the particles on the filter, followed by solution analysis by MC-ICP-MS, yields a precise measurement but one that is biased towards the more soluble components on the filter. Laser ablation however, samples all the different phases on the filter, including more insoluble metal oxides.

Laser sampling can also resolve differences in isotopic composition across a single filter sample. The isotopic composition of large and small particles may vary, particularly if they arise from very different sources. This can be detected, since air flow across filters during collection of particles can lead to uneven distributions of particles of different sizes.

When sampling from the surface of a quartz filter, a raster pattern at very low energy effectively 'dusts' the material from the filter without actually ablating the filter beneath. A photograph (Figure 3) shows the fibers of the filter intact after ablation of the collected dust.



Estimated annual mean background PM10 concentration.

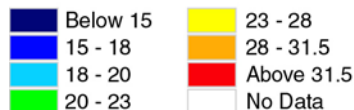


Figure 1: PM10 distribution within the UK in 2001 (left) and proposed reduced distribution for 2010 (right).

Source: www.airquality.co.uk



Figure 2 : Kerbside air quality monitoring station in Marylebone Road, London



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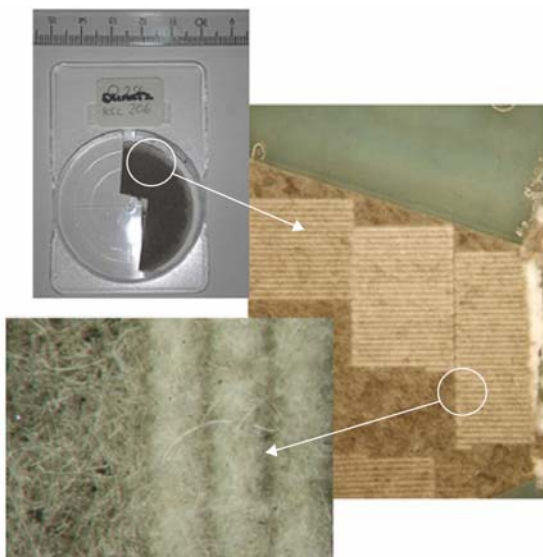


Figure 3: Laser ablation pattern on filter

Analysis by laser is also faster than solution methods, since the chemistry required to leach samples is eliminated. Also, using part, rather than all, of each filter allows a number of filter samples to be loaded into the ablation cell in one batch. A new filter is used every 2-3 days and so a network of sampling stations can generate a large number of filters. To conduct a regional investigation of the Pb isotope composition of PM10's, laser ablation sampling was therefore preferred.

Standardization

A New Wave Research 266nm Nd:YAG laser, Model UP266, was coupled to a Multicollector ICP-MS. Instrument calibration for laser sampling was achieved using a reference solution (NBS 981) including a thallium dope for mass bias correction. A thallium-only solution was aspirated via a micro concentric nebuliser during sample ablation.

Results

The isotope composition of lead emitted from industrial processes and from leaded petrol has a regional signature, resulting from lead ores extracted from "local" rocks and dominant, globally significant lead deposits. Figure 4 illustrates the global lead-isotope compositional variation of PM10 particles; the significant regional differences throughout the world allow us to determine the likely origin of different PM10 samples and to better understand the transport

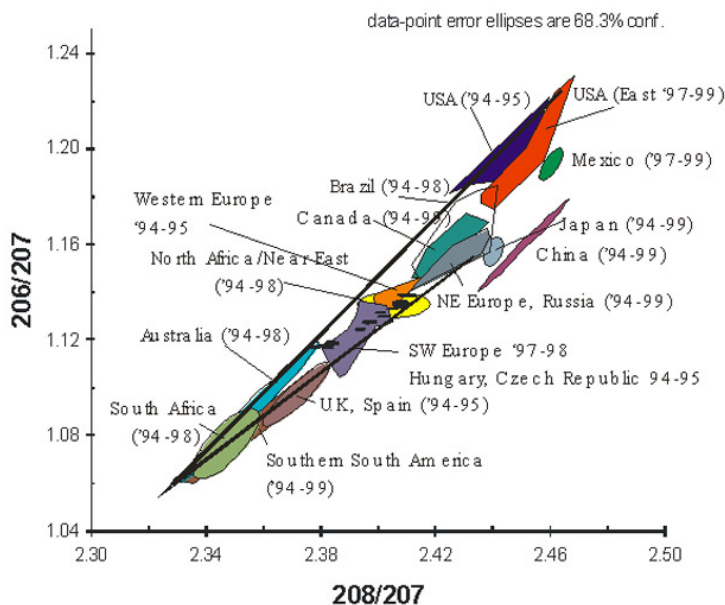


Figure 4: Global Pb isotope signature of PM10's (Bollhöfer & Rosman, Geochim. Cosmochim. Acta 65 1727-1740.)

processes of aerosols both near and far. Furthermore, lead from petrol has, in the past, dominated the lead isotope composition of particulates in our cities but the almost universal recent use of unleaded petrol has gradually diluted the influence of petrol lead, so that we can now detect other sources of lead in collected samples. For example, when the wind direction is from the east, Western Europe is able to see lead contributions from Eastern European sources.

In the same way, more local industrial sources may be identified, since each process such as rubber manufacture or metal refining has its own unique combination of starting materials and hence isotopic characteristics.

Summary

The increasing use of automated sampling stations for the monitoring of air quality provides an excellent source of samples from which to characterise pollutants. The study demonstrates that there is great potential for representative isotopic analysis of the Pb components of PM10 particulates on air filters using LA-MC-ICP-MS.

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Matt Horstwood & Steve Noble from the NERC Isotope Geosciences Laboratory, Nottingham, UK, and Steve Smith & Environmental Research Group, King's College London, UK.



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