

Air Monitoring

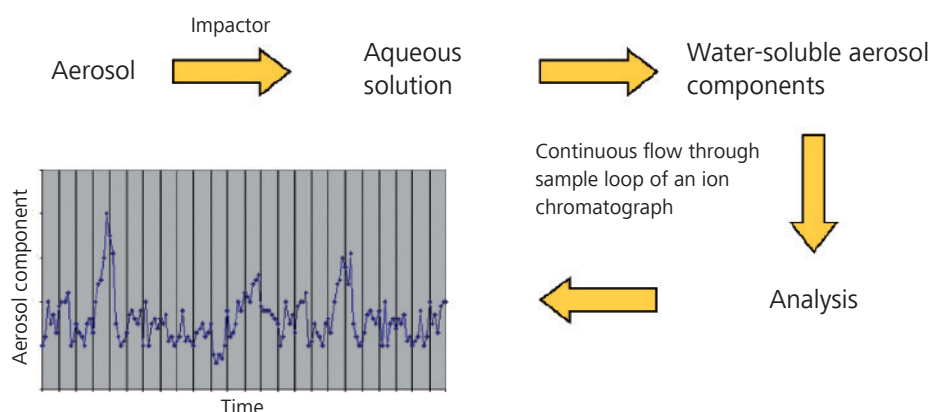


Semi-continuous determination of ambient air quality

The Particle Into Liquid Sampler – a simple solution for the determination of ions in aerosol particles

Combustion of fossil fuels for energy production pollutes the environment with large quantities of harmful substances in the form of gases or aerosols. These emissions cause damage, not only at their source, but also far away from it. The chemical and physical properties of the emissions from anthropogenic as well as natural sources are highly relevant to the climate and the environment.

The Particle Into Liquid Sampler, or PILS¹ for short, samples aerosol particles from an air flow and brings them into the aqueous phase. Subsequently, they can be analyzed using ion chromatography or voltammetry. In order to analyze the gas phase, we recommend the 920 Absorber Module or a MARGA² system, available from Metrohm Applikon.

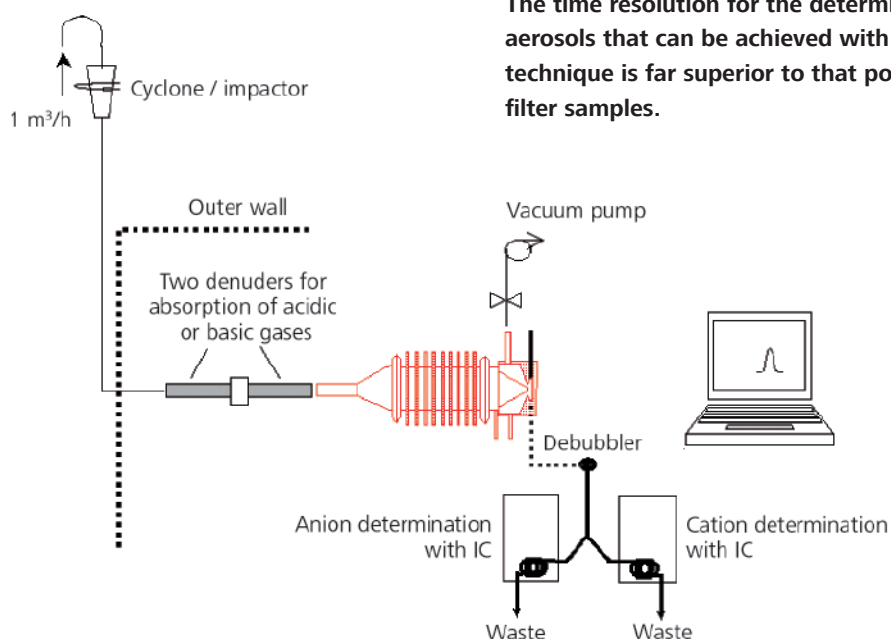


Flow diagram for Particle Into Liquid Sampler combined with ion chromatography (PILS-IC)

PILS mode of operation

The PILS puts aerosols into a supersaturated water vapor phase, where they quickly grow into droplets. These droplets are separated on the basis of their inertia and pumped on with a carrier fluid, which contains an internal standard to allow simple quantification. Air bubbles that are present are removed in a so-called debubbler, and the aqueous phase is transferred to an ion chromatograph, for example, for analysis.

The size of the aerosol particles to be determined is limited by a cyclone or an impactor at the inlet. This makes it possible, for example, to analyze particles smaller than 1 μm , 2.5 μm or 10 μm (PM₁, PM_{2.5}, PM₁₀). To prevent interferences, the gases are absorbed by denuder systems. A vacuum pump produces an air flow in the system with a flow rate of 1 m³/h.



The time resolution for the determination of aerosols that can be achieved with this simple technique is far superior to that possible with filter samples.

¹ PILS is a coproduction of Metrohm Applikon and Metrohm.

² Monitor for Aerosols & Gases in ambient Air.

Advantages of the PILS

- Determination of ions in aerosols with high temporal resolution
- Simple interfacing to an ion chromatography and voltammetry system
- High sampling rate
- Diurnal variation analysis with high time resolution
- Direct on-site sample analysis
- Contamination-free aerosol collection technique (particles PM_{10} , $PM_{2.5}$, PM_{10})
- No sample storage required
- Direct analysis without any further sample preparation

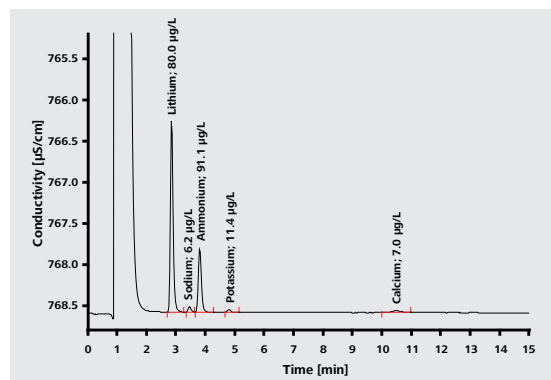
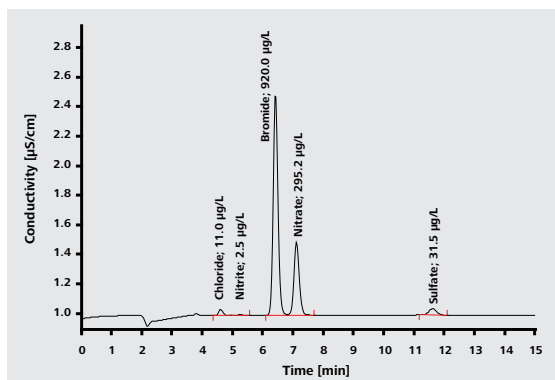
03

Application areas

The PILS can be directly coupled with various analytical techniques. With ion chromatography, water-soluble anions and cations can be determined simultaneously. Heavy metals can be determined using a voltammetric measuring stand. The PILS can also be used for offline sampling with an autosampler. Other examples are the determination of total organic carbon (together with a TOC Analyzer) or interfacing with ICP techniques.

Application areas for PILS – IC:

- Monitoring of pollutants inside buildings
- Emission control at the workplace for worker protection
- Monitoring of outside air
- Measurements of tunnel air
- Determination of stack emissions
- Mobile use, for example on aircraft



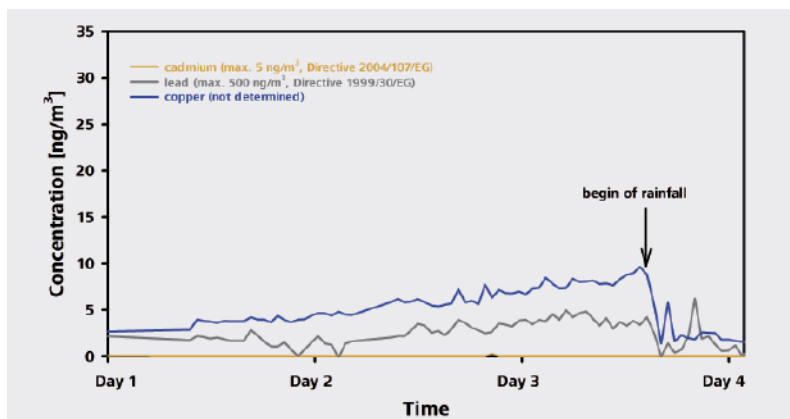
Anion and cation chromatogram for outside air determination and aerosol particles smaller than $2.5 \mu m$ ($PM_{2.5}$). Lithium bromide was used as an internal standard.



Heavy metal determination using PILS-VA

Combining a PILS with a 884 Professional VA enables semi-continuous determination of a range of heavy metals (Cd, Pb, Zn, Cu, Ni, Co, etc.) in particulate matter. The high time resolution records even the smallest changes in the chemical composition of aerosols. In the example

analysis below, the copper and cadmium concentrations in the air rise constantly over several days, up to the point where the rain that sets in washes the majority of the copper and cadmium out of the air (wet deposition).

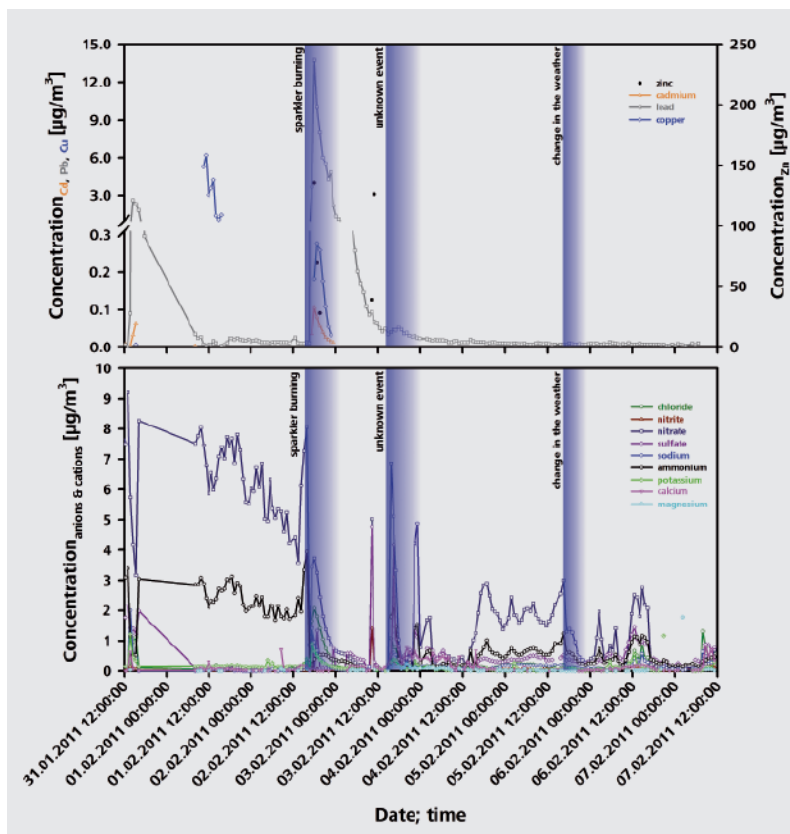


Semi-continuous voltammetric determination of heavy metal content (Cd, Pb, and Cu) in outside air samples from Herisau (Switzerland), using a PILS sampling system.

Standard ion and heavy metal determination using PILS-IC-VA

Coupling with multiple analyzers simultaneously is also possible. In the case of PILS-IC-VA, particles brought into solution are transferred in three streams to a dual channel

ion chromatograph for anion and cation analysis, and to a voltammetric measuring stand for heavy metal cation determination.



Semi-continuous ion chromatographic determination of anion and cation content, and voltammetric determination of heavy metal content in outside air samples from Herisau (Switzerland). To simulate contamination events, sparklers that had previously been immersed in heavy metal salt solutions were burned.

The 920 Absorber Module – an automatic gas sampler

The 920 Absorber Module can also be used as a semi-online sampler. In this case, the gaseous compounds (NH_3 , HNO_2 , HNO_3 , HCl , SO_2) are absorbed directly in a solution over a defined period of time. An external gas flow meter keeps the gas flow constant throughout this period. The absorbent selected should have a high level of solubility for the gas flow and also be affordable. Typically, ultrapure water is used.

The Liquid Handling controlled by the MagIC Net software includes sample preparation, as well as all rinsing procedures. The collected sample can then be transferred directly to an ion chromatograph for analysis.

Additionally, the analytical system can be calibrated automatically from a single multi-ion standard using Metrohm intelligent Partial Loop Technique (MiPT). Since MiPT allows for flexible injection volumes (4–200 μL), it covers a wide range of concentrations.

A 10-port valve, a 6-port valve, and two 800 Dosinos are available for the entire Liquid Handling.

As a result, the 920 Absorber Module can be used to monitor volatile organic acids in process exhaust gases, for example, or in the ambient air at workplaces.



The 920 Absorber Module (right) is able to collect samples fully automatically and transfer them to the 930 Compact IC Flex (left), for example, for ion chromatographic determination.

Features and benefits of PILS-IC-VA

Fully automated analysis

Once the sample table has been created in the MagIC Net software, the PILS-IC-VA system operates fully automatically. The voltammetric determination is synchronized and the measuring results are transferred directly to the MagIC Net database.

No time-consuming sample preparation

The samples are directly brought into solution by the Particle Into Liquid Sampler. The next step is straightforward analysis by ion chromatography or voltammetry without any subsequent time-consuming sample preparation or storage, something that would be required with filter samples, for instance.

Analyses at hourly intervals

The samples are collected and analyzed fully automatically at hourly intervals. Semi-continuous analysis enables considerably higher time resolution than conventional techniques, particularly those involving filters.





Multi-parameter monitoring

With this combination, both standard anions and cations as well as heavy metals can be determined in a single analysis. The software automatically calculates the corresponding concentrations in the air.

High flexibility

The PILS is highly flexible. It can also be used for determinations in combination with mass spectrometry or water soluble organic carbon analyzers, for example. Alternatively, the samples can be collected in sample vessels for offline determination, using an autosampler.

Unattended measuring

Thanks to the use of supply bottles and rinsing canisters, automated measurements are possible even over extended period of time. Standardized, automated sampling and analysis ensure superior reproducibility.

Ordering information

Metrohm instruments

PILS

- 2.136.0400 Particle Into Liquid Sampler ADI 2081
- 2.136.0500 Peristaltic pump, 8 channels with 6 rollers
- 6.5335.000 Liquid Handling Set for PILS

IC

- 2.940.2500 940 Professional Vario TWO/Ses/PP
- 6.2832.000 MSM Rotor A
- 6.2842.000 Adapter sleeve for Suppressor Vario
- 2.920.0010 920 Absorber Module
- 6.6059.322 MagIC Net 3.2 Professional

For this system setup, we also recommend a 941 Eluent Production Module.

Voltammetry

- 2.884.1110 884 Professional VA semiautomated for MME
- 2.843.0240 843 Membrane Pump Station for Professional VA/CVS systems
- 6.5339.030 VA Electrode equipment with MME pro
- 6.6065.202 viva 2.0

Columns

- 6.1006.510 Metrosep A Supp 5 - 100/4.0
- 6.1006.500 Metrosep A SUPP 4/5 Guard/4.0
- 6.1050.410 Metrosep C 4 - 100/4.0
- 6.1050.500 Metrosep C 4 Guard/4.0

Further application-specific equipment

For sample delivery it is possible to use a vacuum pump with a drying system made by KNF (vacuum pump N860.3FT.40.18). The gas phase is separated with denuder systems (e.g., Multi Channel Annular Denuders made by URG, model no. URG-2000-30x242-4CSS). Inlet systems such as the cyclones made by URG (e.g., PM 2.5 URG, model no. URG-2000-30EH) allow aerosols to be differentiated by particle size.



www.metrohm.com

 **Metrohm**