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The potential of the Aerosol Chemical Speciation Monitor for Long-Term Monitoring

Thanks to BAFU, Empa for financial support and collaboration
• Introduction

• Aerosol chemical speciation monitor versus Aerosol mass spectrometer

• First results

• Conclusions/Outlook
Research grade Aerosol mass spectrometer

ToF mass spectrometer

Ambient Pressure Sampling Orifice

Aerodynamic Particle Focusing Lens

Particle Beam TOF Chopper

Turbo Pump

Heater (typically 600°C)
Time series (time resolution seconds to minutes) of PM1 (in the future also PM2.5 possible).
Black or elemental carbon or other refractory components must be measured by other instruments than AMS.
Real-time measurement of aerosol particles with the AMS

Aerosol Sampling

Real-time measurement

AMS

Nitrate
Sulphate
Ammonium
Organics → Hydrocarbons
Oxygenated
Etc..

Mass Size distribution

Chemical composition
Mobile measurements possible
AMS measurements in and around Switzerland
Chemical composition of PM1 without BC in Central Europe

AMS-aerosol components [%]

- organic matter (OM)
- sulfate ($SO_4^{2-}$)
- ammonium ($NH_4^+$)
- nitrate ($NO_3^-$)
- chloride (Cl)

Swiss Plateau

- summer
- winter

Alpine region

- elevated (spring)
- low (winter)

Lanz et al., ACP, 2010
Positive Matrix Factorization (PMF) of full OM spectrum for source identification and attribution

Lanz et al., ACP, 2007
Ulbrich et al., ACP 2009
Chemical components of organic aerosol

- OOA: mostly Secondary organic aerosol
- HOA: mostly organic aerosol from traffic
- P-BBOA: mostly wood burning

Lanz et al., 2010
Composition and organic components in the northern hemisphere

- Data are based on campaigns of 3-5 weeks

HOA: mostly fossil combustion like traffic

OOA: mostly secondary

Other OA: e.g. wood burning, cooking

Jimenez, Prevot et al., Science, 2009
2. The ACSM instrument - Scheme

Particle Beam Generation

Particle Sizing

Particle Composition

Quadrupole Mass Spectrometer

HR-TOF

Aerodynamic Lens
40-1000 nm

Particle Inlet (1 atm)

Chopper

Thermal Vaporization & Electron Ionization

Internal standard

Pumps
Aerosol mass is determined from difference of ‘Sample – Filter” mode
2. The ACSM instrument - Naphthalene

Naphthalene used for e.g.,
-m/z calibration
Example of comparison of time trends ACSM/AMS

sulfate

organics
ACSM in Zurich during one year
February 2011 – February 2012

- Data coverage very good
- Missing data due to some deliberate instrument tests but usually due to problems with inlet valve
Maintenance and issues

• Fixing the inlet valve a few times

• Calibration once a month seems to be sufficient

• Data analysis. The assessment of the collection efficiency (mostly bounce off the heater) is one of the most important issues in AMS (this is true for all AMS). Measurements of PM$_1$ or PM$_{2.5}$ in the future is highly recommended
Levoglucosan

Wood burner (emissions) chestnut, very inefficient burning

Night period in Roveredo in March, more than 80% of OC non-fossil

Average in Roveredo over the whole December

Mass spectra from a Motorway site in May
Oxidation characteristics: former studies

\[ f_{43} = \frac{m/z \ 43}{\text{total Organics}} \quad f_{44} = \frac{m/z \ 44}{\text{total Organics}} \]

\( f_{43} \) mostly the oxidized \((C_2H_3O^+)\) ion mostly from non-acidic functional groups

\( f_{44} \) marker for oxidation \(\Rightarrow (CO_2^+)\) mostly from carboxylic groups \((Ng \ et \ al., \ 2010)\)
ACTRIS one-year campaign starting June 2012

EMEP special observation periods: June 8 – July 17; January 15 – February 15
Conclusions / Outlook

• The ACSM is an instrument that can be used researchers but also by the authorities. There were rumours that the French government planned to buy 40 ACSMs. There are projects for several ACSMs in Sweden, several ACSMs around Lyon…

• Within 2012, around 15 (soon likely many more) ACSMs will be operational in Europe

• Goal: Characterization of composition of PM1 (later years probably PM2.5). Quantification of sources or organic aerosols (traffic, wood burning, cooking, secondary organics) over a whole year

• The combination of the ACSM with the multi-wavelength light absorption measurement (e.g. new Aethalometer) is recommendable to provide source apportionment of BC as well

• Value of monthly campaigns strongly enhanced if embedded in year-long measurements

• New ACSM (ToF-ACSM) maybe becomes available in 2012 (even smaller). Tests will be performed at Jungfraujoch

• AMS measurements also possible off-line from Hi-Vol-filters (Very similar spectra can be obtained)