Instrument Overview

Sat Sept 8  9:40 – 10:10

19th AMS Users Meeting
Washington University, St. Louis

SN 001 to 004

It's been a while...
# Aerodyne Mass Spectrometer Systems

## Aerosol Instruments
- QAMS
- CTOF AMS
- HTOF AMS
- SP HTOF AMS
- CTOF mini-AMS
- LTOF AMS
- QACSM
- eTOF ACSM

## Gas Phase Instruments
- APi – TOF
- IMS – TOF
- EI-TOF
- VOCUS PTR
- Mini-GC (EI TOF, CIMS/VOCUS)

## Sources
- IMR (I⁻, SF₆⁻, H₃O⁺, Acetate,…)
- Nitrate (NO₃⁻)
- FIGAERO

### Tofwerk, AG Mass Spec Partner

Most instruments available with C, H or L ToF MS
## AMS Components and Other Aerodyne Instruments

### Components
- SP – Soot Particle module
- LS – Light Scattering module
- Aerosol Dryer
- Thermal Denuder
- PAM – OFR
- Pressure Controlled Inlet
- EyeOn control system
- Beam Width Probe
- Auto Valve System

### Instruments
- TILDAS (IR trace gas measurement)
- CAPS (NO2, PMex, SSA)
- TWST (Cloud optical depth)
- DPAS (BC conc. Zhenghong Yu)
- ARISense (Air quality monitoring package)
Aerosol Mass Spectrometer

High Performance TOF mass spectrometer

PM2.5 Lens
Aerodynamic Lens

MS

BWP
Capture Vaporizer

ePTOF
Light Scatter module
Laser Vaporizer (SP module)

Particle TOF Region

Aerodynamic Sizing

Data Acq Analysis

Particle Position

Fast Data System Timers

RIEs, f44

Thermal Vaporization & Electron Impact Ionization

Particle Beam Generation
Aerodynamic Sizing

Pumps (x5)

DACs

RIEs, f44
Long (L) TOF AMS

2x the resolution of HTOF (Vmode) with the same sensitivity.
2x the length of the HTOF

55” L x 24” D x 27” H, 275 lbs.
[139.7 cm x 60.9 cm x 68.6 cm, 124.7 kg]
Resolution of C-TOF, H-TOF and L-TOF
Qualitative Comparison of LTOF to C- and HTOF

Improved ability to report on elemental Nitrogen.
Particle Inlet (1 atm)

Thermal Vaporization & Electron Impact Ionization

Aerodynamic Lens 40-1000 nm

Particle Beam Generation

No Sizing

Particle Composition

Smaller/lower cost Q- or TOF- Mass Spec

Laptop Computer

Pumps (x3)

Aerosol Chemical Speciation Monitor
QACSM and ToF ACSM Systems

QACSM

For routine monitoring

eTOF ACSM

Higher performance version
Faster data rate (~1 min).
ToF ACSM and mini-AMS Systems

Differences between ACSM and mAMS are the MS, chopper and the DAQ system
All AMS and ACSM Systems Share Some Common Features

- Particle aerodynamic lens
- A differentially pumped high vacuum system, *efficient gas-particle separation*
- Particle vaporizer
- Electron impact ionization source
- Mass spectrometer ➤ performance/Cost
ACTRIS-ACSM intercomparison Studies in Paris 2013, 2016 and 2018

Aerosol Chemical Speciation Monitor Calibration Centre (ACMCC at CNRS SIRTA Lab, France)

10 European countries

15 mass spectrometers
13 QACSM, TOF ACSM, HTOF AMS

Now led by Evelyn Freney and Olivier Favez
PM2.5 Capability

Sampling system, inlet plumbing

PM2.5 Particle lens

Capture vaporizer

Sample in from cyclone

Inlet

Filter

3-way valve

IPL

ACSM or AMS

To sampling pump

Xu et al, AS&T 2017

Yunjiang Zhang et al, ACP, 2017

First PM2.5 QACSM instrument

Jian Zhao/Yele Sun - IAP
PM2.5 Lens Transmission

(a) IPL lens pressure ~ 3.8 torr
- NH$_4$NO$_3$ with SMPS correction
- NaNO$_3$ Eq. 3
- PSL Eq. 3
- mini-ToF-AMS
- NH$_4$NO$_3$
- Eq. 4 with CPMA
- Eq. 5 with CPMA
- US EPA WINS
- PM$_1$ lens pressure ~ 1.3 torr
- Standard lens (Liu et al. 2007)

(b) Velocity (m/s)

Vacuum aerodynamic diameter $d_{vac}$ (nm)

Xu et al, AS&T 2017
Particle Vaporizer Types

SV - Standard Vaporizer

(a) Standard Vaporizer

(b) Standard Vaporizer

CV - capture Vaporizer

(c) capture Vaporizer

Xu et al, AS&T 2017

Hu et al,
ACS Earth and Space Chemistry (2018)
Stand-Alone TAG System for use with standard GCMS systems

Collection and Thermal Desorption cell (CTD) and valveless injector

Wen Xu, Conor Mackinson, Aerodyne

Nathan Kreisberg, Aerosol Dynamics
Allen Goldstein, UC Berkeley
TAG System on Agilent GC-MS

Wen Xu, Nathan Kreisberg
Summer 2004
First TAG field deployment.

*When TAG and AMS met*

**ICARTT Measurements at Chebogue Point**

- ICARTT campaign at Chebogue Point during summer of 2004.
- Full range of meteorological, radiation, trace gas, and aerosol measurements
- TAG analysis focused on period of July 26 – Aug. 15, 2004 (~3 weeks)
- Hourly data (750 chromatograms x 2 detectors)
- Manual calibration with directly applied standards
- Automated filtered and zero air blanks
An In-Situ Instrument for Speciated Organic Composition of Atmospheric Aerosols: Thermal Desorption Aerosol GC/MS-FID (TAG)

Brent J. Williams, Allen H. Goldstein, Nathan M. Kreisberg, and Susanne V. Hering

1Department of Environmental Science, Policy, & Management, University of California, Berkeley, CA, USA
2Aerosol Dynamics Inc., Berkeley, California, USA
Mini-GC for TOF MS

Brian Lerner, Megan Claflin

- Design a “proper” GC system for commercial sale
  - Couple seamlessly with EI- or Vocus- TOFMS
  - Modular design for flexibility
  - “Light and fast”

Valve oven
- 2-zone control
- Chromatography valves
- Sample loops

Gas deck
- MFCs
- Calibration valves

Data box

Octal temp controller

GC oven

Power supplies
Mini-GC mounted to EI-TOF MS

Brian Lerner, Megan Claflin

- Design a “proper” GC system for commercial sale
  - Shown mated to EI-TOFMS

Valve oven
- 2-zone control
- Chromatography valves
- Sample loops

GC oven

Data box

Octal temp controller

Gas deck
- MFCs
- Calibration valves

Power supplies
PAM Oxidation Flow Reactor

- Technique developed by Bill Brune (Kang et al., ACP, 2007)
- **Includes**: OFR, O₃ chamber, humidifier, autovalve, UV and RH/T sensors
- **Options**: MFCs, UV lamps ($\lambda = 313 – 369$ nm), syringe pump
- Remote control via PAMcontrols software
Thermal Denuder System

For aerosol volatility studies
Aerosol Sample Dryer System

- USB interface to PC
- RH/T - Relative humidity and temperature
- P1 and P2 - 860 torr absolute
- dP - 50 torr differential pressure
- CA - critical aperture

Graph showing relative humidity over time:
- PermaPure PD.200T.12
- Reflux mode
- Counter flow pressure ~550 torr
- Relative humidity before dryer
- Relative humidity after dryer
- 20%
Sample Line Flow Controller System

- Light weight, low power (24V)
- Up to 10 LPM
- Compatible with Dryer system
High Resolution Chemical Ionization Mass Spectrometer - CIMS

- Can be configured with various reagent ionization sources.
- Can also detect naturally occurring ambient ions - Api-TOF
Ion Mobility Spectrometer TOF MS
Separation of structurally similar isobaric compounds.

Low field Drift Tube
P = 1 atm
T = 50 – 150 °C
Resolution > 100
Multiplexing

TOF-MS
Mass accuracy ~ 2-7 ppm
Resolution > 4000

Jordan Krechmer, Manjula Canagaratna
CAPS NO$_2$, PMex and SSA Monitors
Particle Extinction and Single Scattering Albedo

3-wavelength version now available

Andy Freedman/Tim Onasch/Phil Croteau
DPAS Aerosol Absorption Monitor

Real-time and continuous PM detection and quantification with high sensitivity

Dual channel design
PM and NO2

Differential Photoacoustic Absorption Monitor

Zhenhong Yu, Aerodyne
Air Quality Sensor System

Integrates 16 Measurements

- CO, NO, NO₂, Ox, CO₂
- Particle size ~ (0.4 - 17) um, 16 bins
- PM₁, 2.5, 10
- Wind speed, Wind direction
- Solar
- Sound/noise
- Barometric pressure
- Relative Humidity
- Temperature

Use of electrochemical sensors for measurement of air pollution: correcting interference response and validating measurements

Eben S. Cross¹, David K. Lewis¹,², Leah R. Williams¹, Gregory R. Magoon¹, Michael L. Kaminsky³, Douglas R. Worsnop¹ and John T. Jayne¹

Eben Cross
CACC Research Group Focus
Mass Spectrometry for the Study of SOA

Sun

VOC  LVOC  HOM
Oxidation/processing SOA formation

New particle Formation
Condensation and growth
Processing and aging

GC  →  PTR  →  CIMS (I⁻, NO₃⁻)  →  APi
AMS
Decreasing Volatility

Aerosol Composition
Chemical and physical properties

Compare observations from lab and field measurements to better understand gas to particle transformations