CARBONACEOUS AEROSOL MEASUREMENTS ON SPARTAN FILTER SAMPLES

Ann M. Dillner, Jason Giacomo, Chelsey Li, Naveed Anwar

UC DAVIS
AIR QUALITY RESEARCH CENTER

4th International SPARTAN Meeting
Washington University in St. Louis
May 18, 2023
Carbonaceous aerosol measurements in SPARTAN

- **Organic carbon (OC) and elemental carbon (EC)**
  - IMPROVE, U.S. monitoring network, measures EC and OC
    - Thermal Optical Reflectance (TOR)
    - Quartz Filters, destructive analysis
  - SPARTAN collects only Teflon filters for multiple measurements
- **FT-IR** - reproduce TOR OC and EC on Teflon filters
  - Inexpensive and non-destructive
  - Uses ambient OC and EC data to calibrate FTIR
  - Method developed for IMPROVE (Debus et al., 2022)
  - TOR OC and EC - one year at select MAIA sites to improve SPARTAN and MAIA measurements

- **HIPS**
  - IMPROVE measures light absorption, related to EC or BC
  - measure light absorption on SPARTAN and MAIA filters
More Carbonaceous Aerosol Information: Functional Groups and OM

- TOR measures carbon only, assume OM/OC to get OM or OA
- FT-IR measures functional groups
- Weighted sum of functional groups for organic matter (OM)

**Functional Groups**
- Oxalate
- Ammonium oxalate
- Aliphatic C-H
- Carboxylic acid
- Tannic acid, HULIS-like compound
- Alcohol
- Non-acid, non-oxalate carbonyl

**Molecules**
- Suberic acid
- Oxalate
- Tannic acid
- Alcohol
- Non-acid, non-oxalate carbonyl
FTIR measures carbonaceous aerosol from Teflon filters.

This talk

- TOR OC and EC calibrations
- Functional group calibrations
- Clusters/PMF/calibration
- PM, ion and element calibrations
- PM, sulfate, ammonium, nitrate, silicate
- Source information

Sampled teflon filter

FT-IR spectrum
FTIR measures carbonaceous aerosol from Teflon filters

Naveed’s talk

- TOR OC and EC calibrations
- FT-IR OC, EC
- Functional group calibrations
- Functional groups, OM, OM/OC, O/C
- Clusters/PMF/ calibration
- Source information
- PM, ion and element calibrations
- PM, sulfate, ammonium, nitrate, silicate
FT-IR lab in Air Quality Research Center At UC Davis

- Routinely analyze Teflon filters by FT-IR
  - SPARTAN ~2000 filters since 2018
  - MAIA ~150 samples since 2022
  - IMPROVE ~130,000 filters since 2015
  - CSN ~75,000 filters since 2017-2022
  - SEARCH ~5000 filters (2009-16)
- Lab studies and field campaigns
- Methods
  - 5 minutes per filter, ~40 hrs/wk
  - 3 FT-IR instruments
  - Weekly QC
  - Analyzed prior to XRF (Wash U)
Light Absorption

Analysis performed by HIPS

Hybrid Integrating Plate/Sphere

Absorptance: $A = 1 - T/(1 - R)$

HIPS data reported as inferred atmospheric absorption coefficient:

$$F_{abs} \equiv \frac{f}{V} \ln \left( \frac{1 - r}{t} \right)$$

$f = \text{filter deposit area},$
$V = \text{volume of air sampled}$

$F_{abs}$ reported in units of $(\text{Mm})^{-1}$

IMPROVE samples since 1988

SPARTAN samples since 2018
Relationship between light absorption and EC

- Light absorption caused by
  - EC (primarily)
  - Fe
  - Some organics
- Light absorption efficiency varies with composition
- Convert Fabs to $\mu$g/m$^3$ EC
  - Assume absorption efficiency of 10
- Useful to QC FT-IR EC measurements

\[ y = 0.7422x + 0.4148 \]
\[ R^2 = 0.703 \]
QC for functional groups and OC

- Unlike EC, OC has no independent measurement for QC
- Compare sum of components to mass
- Figure suggests some overprediction of functional groups
- Working to improve functional groups, especially sites with high soil and high nitrate
FT-IR spectra of SPARTAN samples

Rehovot, Israel

Dhaka, Bangladesh

O-H, N-H
C-H
C=O

soil

O-H, N-H
C-H
C=O
Functional Group Measurements

Rehovot, Israel, Jan 2021 – June 2022

Dhaka, Bangladesh, Jan 2021- Sept 2021
Measuring Carbon by FT-IR and HIPS for SPARTAN

- FT-IR and HIPS are non-destructive, fast, low-cost method
- Use Teflon filter (SPARTAN sampling)
- Measure organic carbon and elemental carbon
  - OC and EC using FT-IR
  - Calibrate to IMPROVE, next calibrate to MAIA TOR samples
- Measure light absorption for optical measurement and to QC FT-IR EC
- Measure organic functional groups
  - Same FT-IR spectra as OC and EC
  - Composition of OM
  - Sources