

Small Chamber Measurement of Sulfur Gas Emissions from Drywall

Randy Maddalena

Indoor Environment Department
Lawrence Berkeley National Laboratory

Objectives



- Identify composition of chemical emissions from drywall
 - Volatile organic chemicals (VOC)
 - Aldehyde (ALD)
 - Volatile sulfur chemicals (VSC)
 - Reactive sulfur gasses (RSG)
- Quantify emission factors
 - Measure chemical specific emission factors for drywall samples under standard conditions
 - Characterize influence of environmental factors (temperature, relative humidity, ventilation, coatings)

Approach

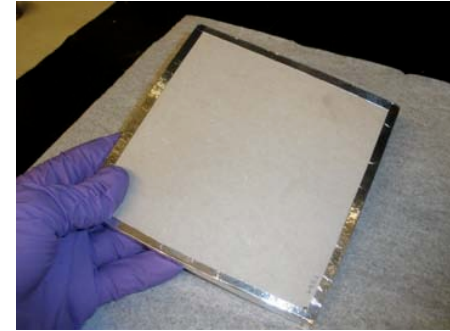
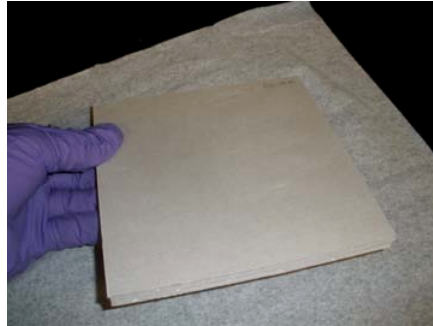


- Samples received from CPSC assigned unique tracking number, packaged individually in Tedlar film
- Samples stored individually wrapped in Tedlar at room temp until testing
- Cut to size (edges sealed)
- Precondition in clean chamber
- Transfer to emission chamber
- Measure steady state conc.
- Calculate emission factors

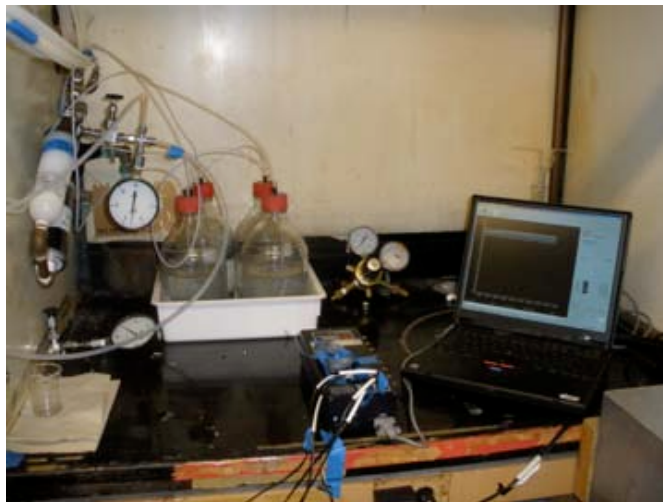


Sample Preparation

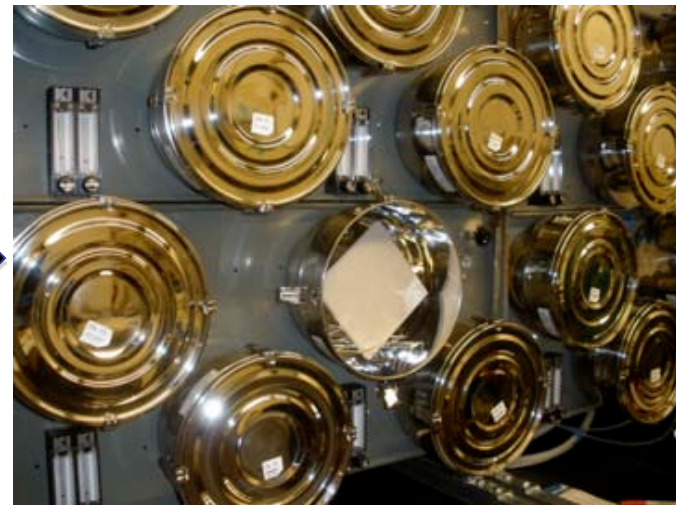
- Sized to ~ 6" square with edges sealed using low VOC aluminum tape
- Front and back faces remain exposed



- Materials isolated and conditioned at room temp & constant RH under continuous stream of carbon/HEPA filtered air



Humidity control

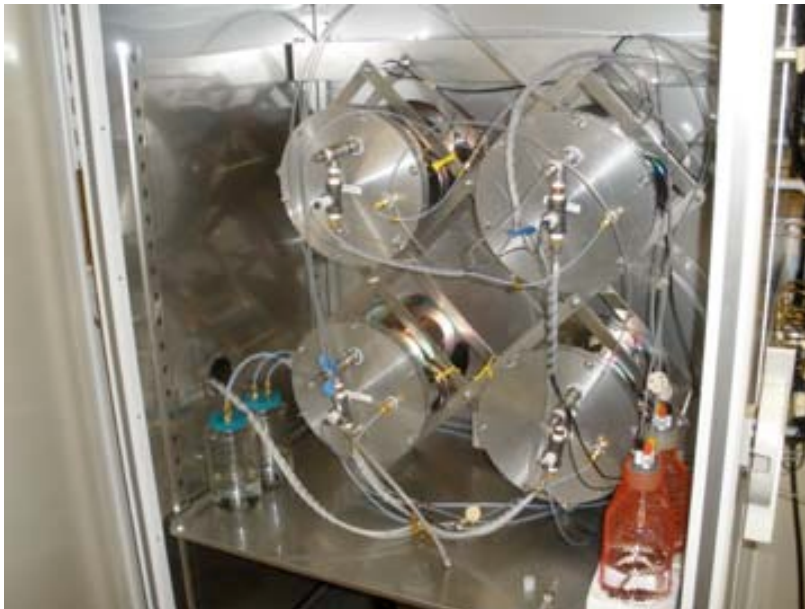


Conditioning chambers

Emission chamber testing



- **Dynamic emission chambers provide controlled inert environment to achieve steady state concentration (emission)**
 - All wet surfaces are low sorption (Sulfinert[®] and Teflon)
 - Chamber volume 10.75 Liters
 - Ventilation 0.5 to 1 LPM (ACH = 2.8 - 5.6 h⁻¹)
 - Temperature 25 C (~ 77 F)
 - Relative humidity ~50%



Chemical sampling and analysis



- **VOCs and VSCs (boiling points greater than carbon disulfide)**
 - Air collected from chambers on tenax/carbosieve thermodesorption tube
 - Sample desorbed onto cryogenically cooled GC inlet
 - Individual compounds chromatographically separated by GC
 - Detection by mass spec (MSD) or Sulfur Chemiluminescence (SCD)
 - Identification from mass spectra (NIST08), retention time and/or pure standards
- **Low molecular weight carbonyls**
 - Air collected from chamber on DNPH coated silica gel cartridges
 - Sample extracted from cartridge with acetonitrile
 - Extract analyzed by HPLC
 - Compounds identified by retention time of pure standard
- **Reactive sulfur gases & VSCs**
 - Solid Phase Micro Extraction (SPME) sampled directly from chamber
 - SPME desorbed on cryogenically cooled GC inlet
 - Quantification with SCD and gas-phase calibration

Calculations



- Chemical-specific emission factors

$$EF = \frac{f \times (C - C_0)}{A}$$

EF = emission factor, $\mu\text{g}/\text{m}^2/\text{h}$ or $\text{ng}/\text{m}^2/\text{h}$

f = ventilation flow rate, m^3/h

C = measured concentration after ~ 6 air changes, $\mu\text{g}/\text{m}^3$ or ng/m^3

*C*₀ = measured background concentration, $\mu\text{g}/\text{m}^3$ or ng/m^3

A = projected surface area of material, m^2

$$EF = \frac{(C - C_0) \times ACH}{L}$$

EF = emission factor, $\mu\text{g}/\text{m}^2/\text{h}$ or $\text{ng}/\text{m}^2/\text{h}$

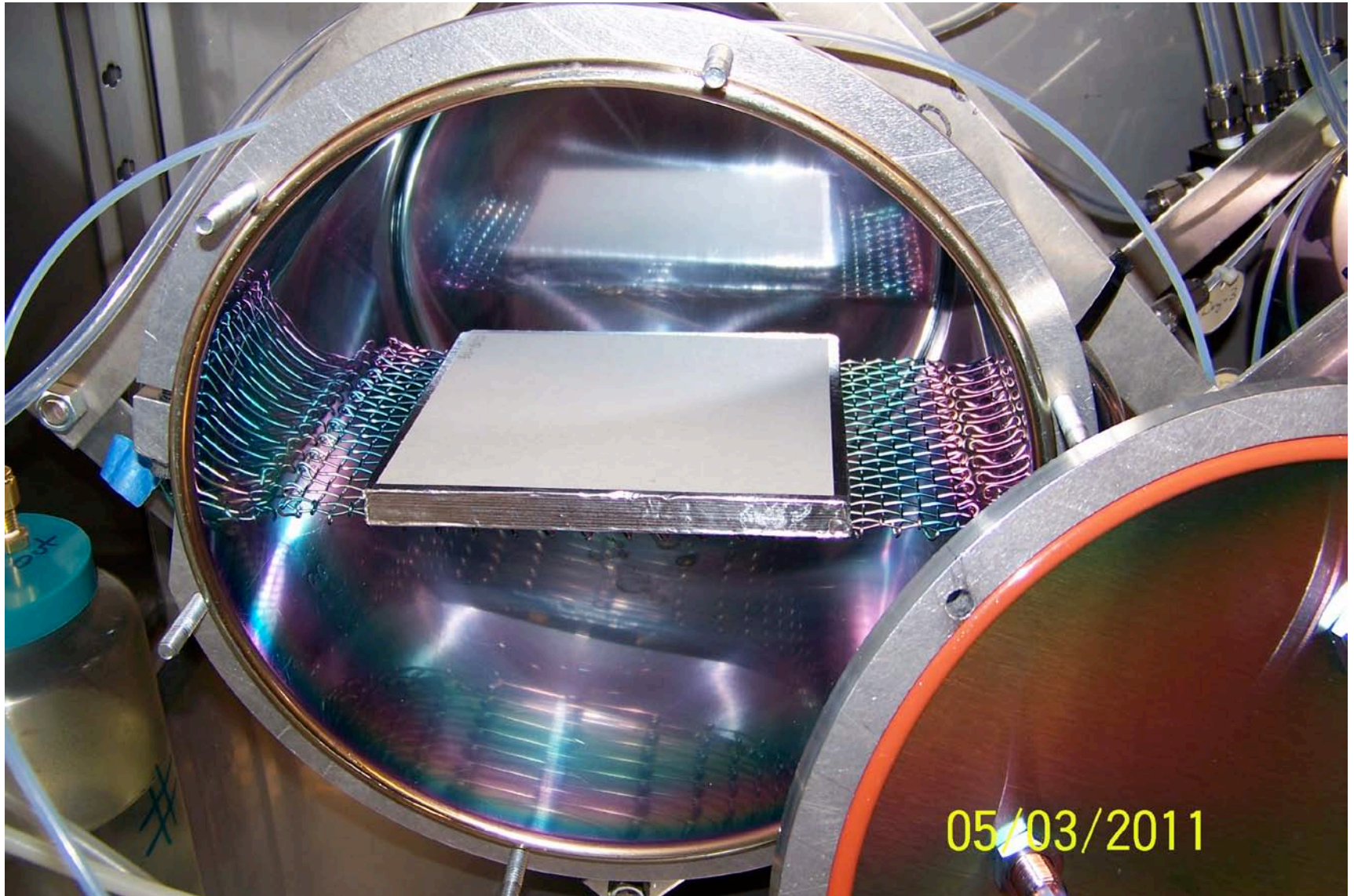
ACH = air change rate h^{-1}

C = measured concentration after ~ 6 air changes, $\mu\text{g}/\text{m}^3$ or ng/m^3

*C*₀ = measured background concentration, $\mu\text{g}/\text{m}^3$ or ng/m^3

L = material loading factor, m^2/m^3

Loaded test chamber



Test Chambers



SPME Holder



SPME fiber extended



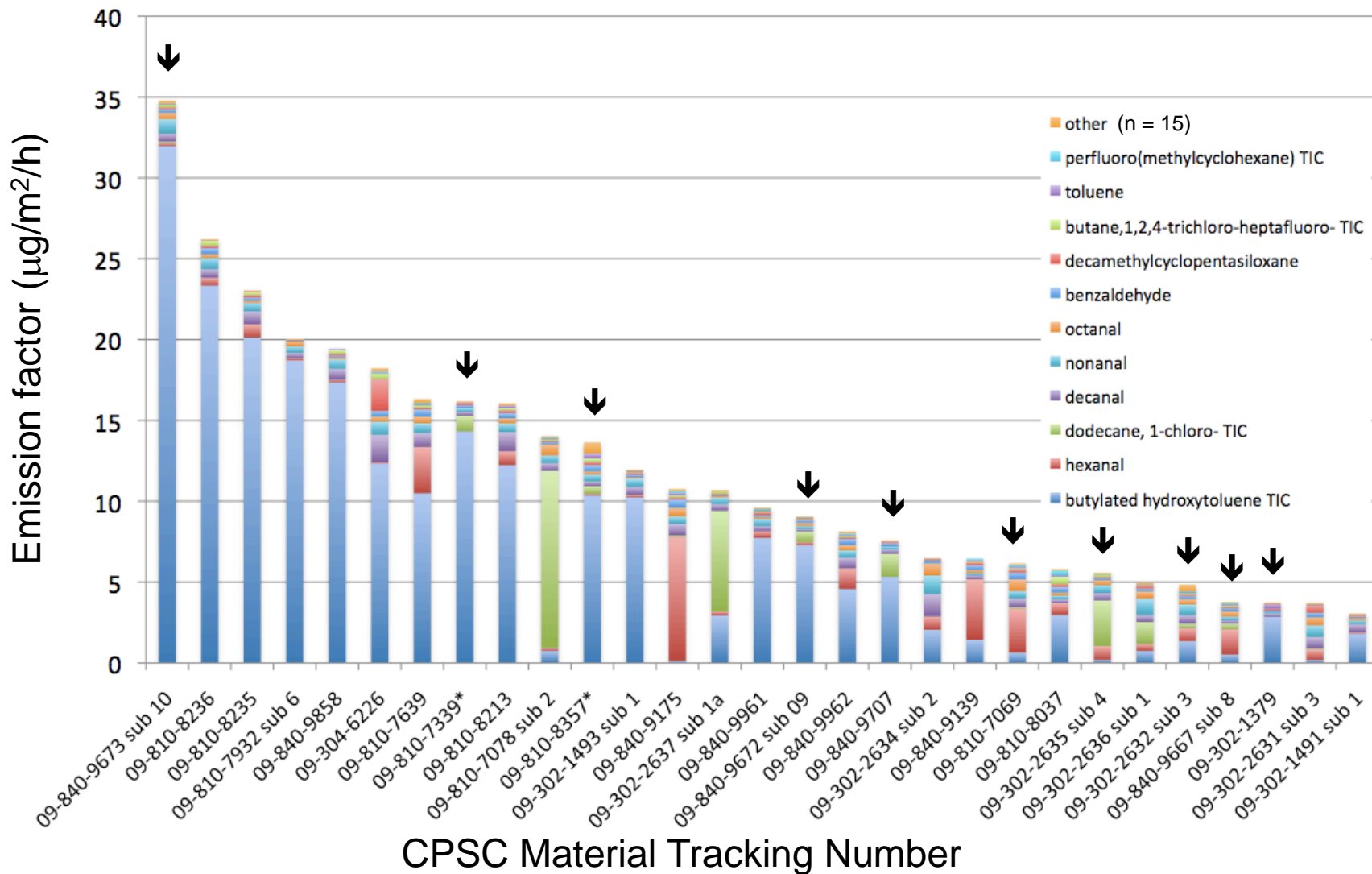
Thermal desorption tube



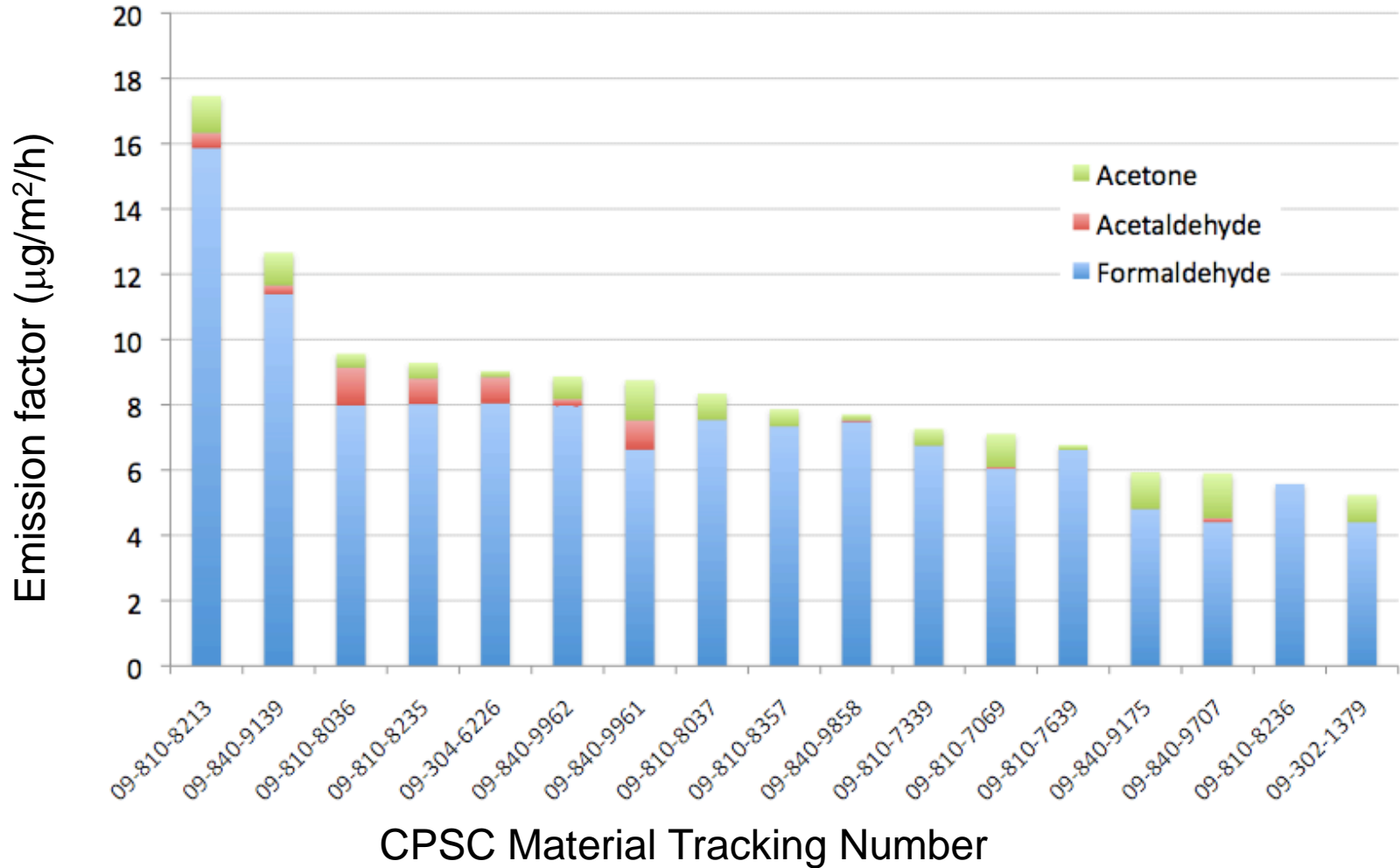
Active sampling



VOC Emission Factors



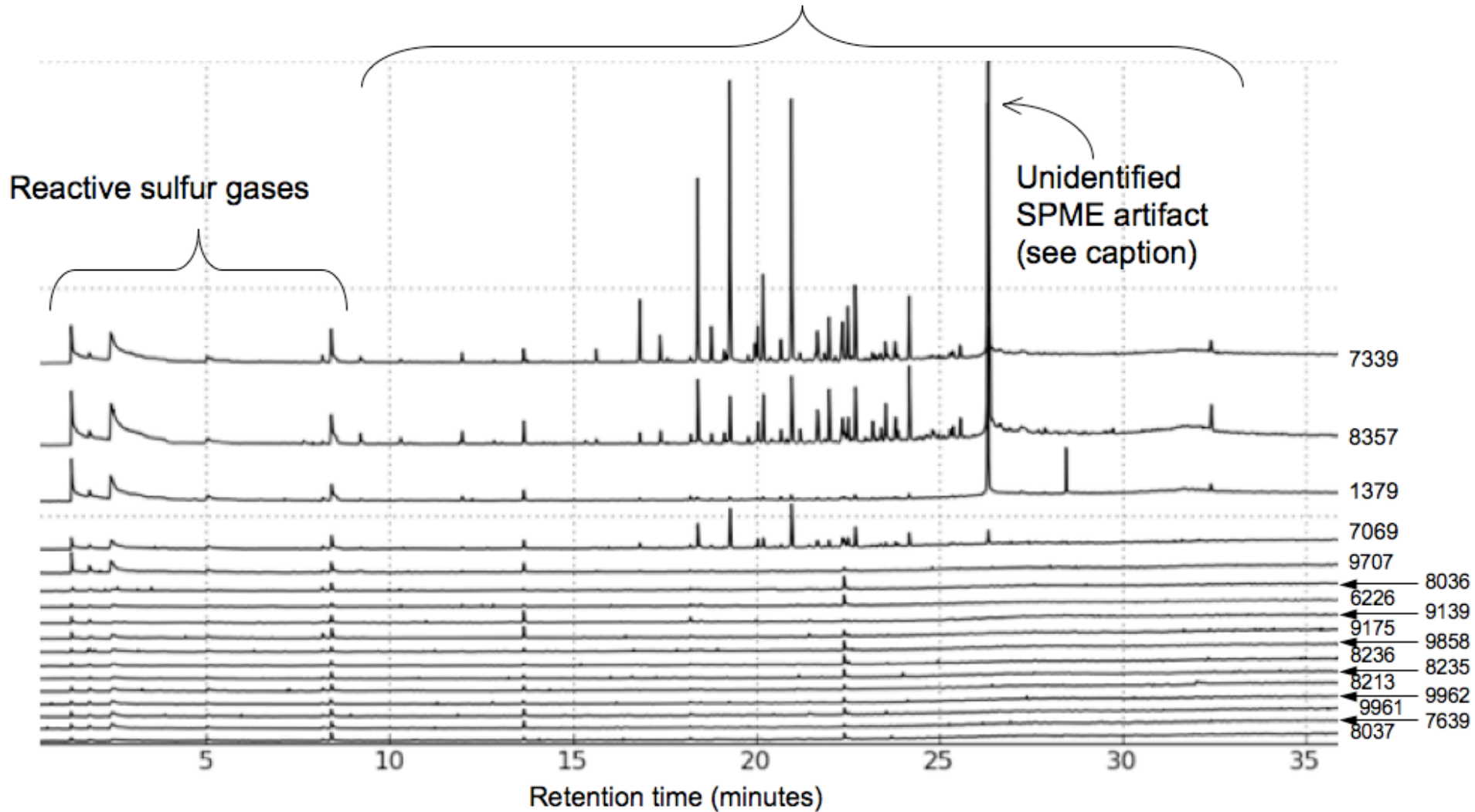
Carbonyl Emission Factors



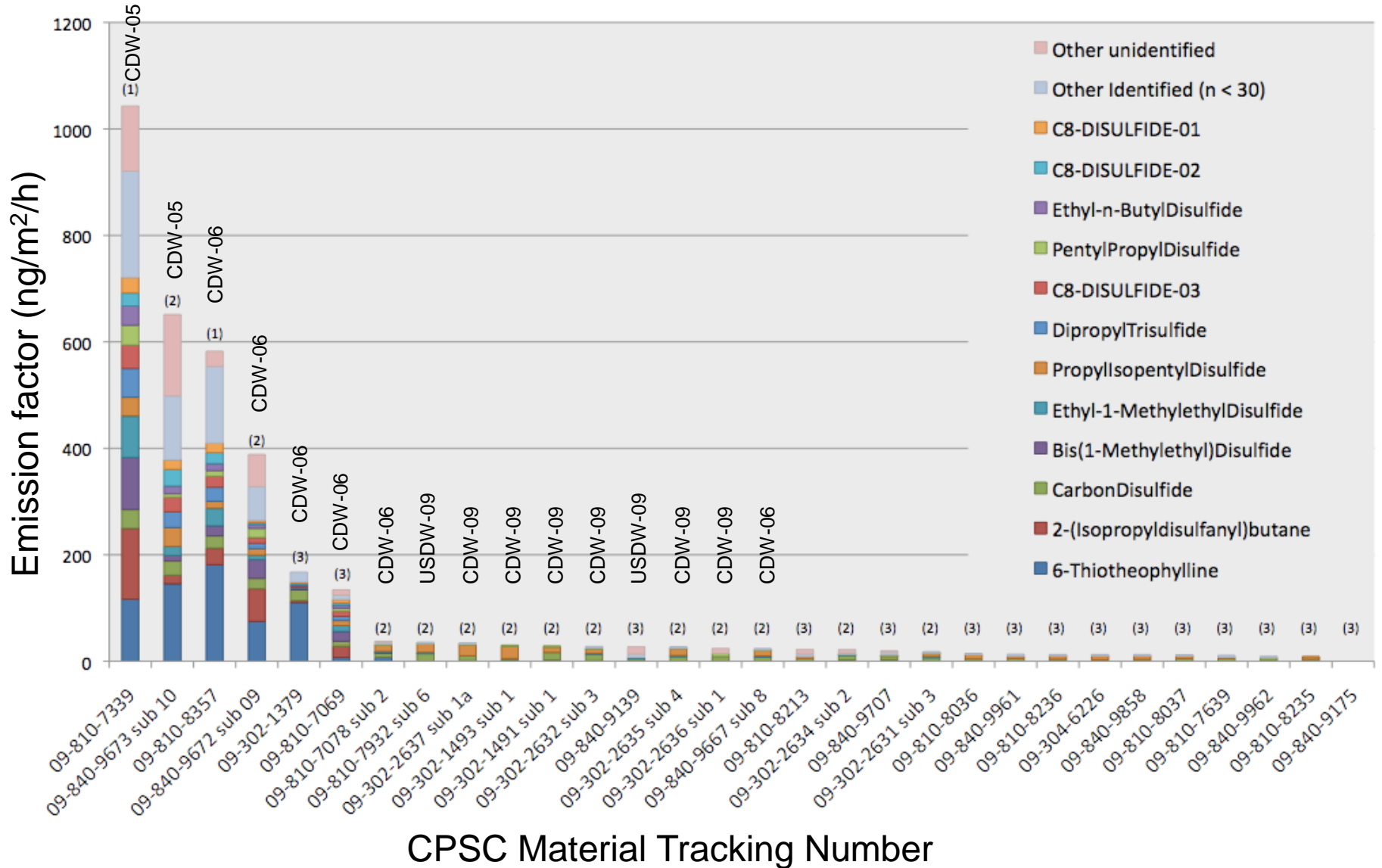
SPME Chromatograms



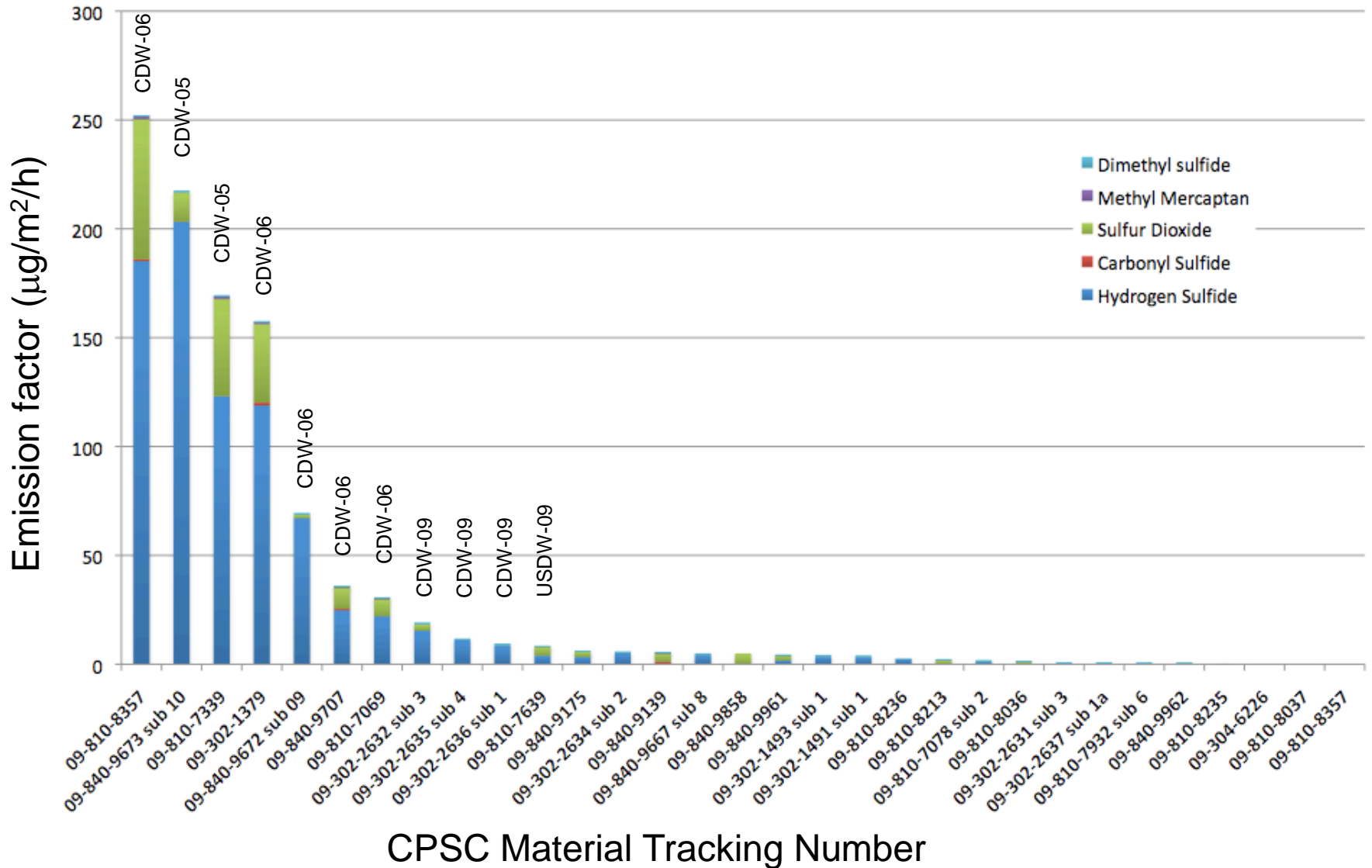
Volatile sulfur compounds



VSC Emission Factors



RSG Emission Factors

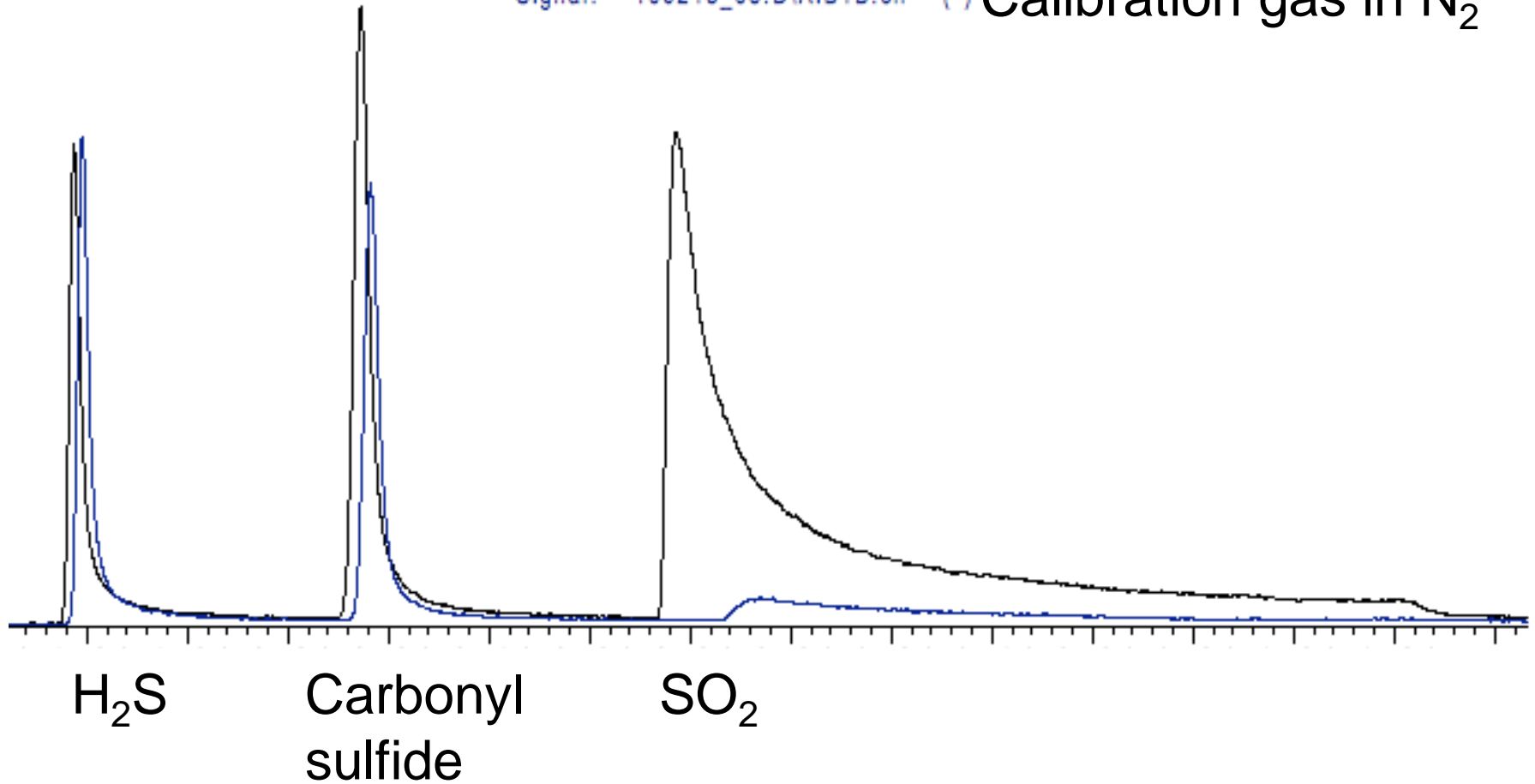


SO₂ SPME Artifact



Signal: 100210_04.D\AIB1B.ch
Signal: 100218_05.D\AIB1B.ch (*)

Calibration gas in air
Calibration gas in N₂



Findings



- **Standard emission factors measured**
- **T/RH effect measured**
 - Chemical fingerprint changes at elevated RH
 - Emission rates increase with increasing T
- **Front/back comparison completed**
 - No significant difference

Findings



- **Coated/uncoated comparison complete**
 - No significant difference
- **Initial deposition rate on surfaces**
 - Chinese drywall emission source introduced into chambers with different materials
 - Comparison of upstream/downstream concentrations
 - Drywall, carpet, wood panel testing complete

Findings



- **Thermal desorption active sampling**
 - method susceptible to humidity
 - limited to gases with boiling point $> \text{CS}_2$
- **SPME fiber passive sampling**
 - Method susceptible to SO_2 artifacts
 - Sampling rate dependant on T and RH
 - Requires rapid/consistent transfer from collection to analysis