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 one cryogenically cooled GC inlet
  – Quantification with SCD and gas-phase calibration
Calculations

- Chemical-specific emission factors

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

- EF = emission factor, \( \mu g/m^2/h \) or \( ng/m^2/h \)
- \( f \) = ventilation flow rate, m\(^3\)/h
- \( C \) = measured concentration after ~ 6 air changes, \( \mu g/m^3 \) or \( ng/m^3 \)
- \( C_0 \) = measured background concentration, \( \mu g/m^3 \) or \( ng/m^3 \)
- \( A \) = projected surface area of material, m\(^2\)

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

- EF = emission factor, \( \mu g/m^2/h \) or \( ng/m^2/h \)
- \( ACH \) = air change rate h\(^{-1}\)
- \( C \) = measured concentration after ~ 6 air changes, \( \mu g/m^3 \) or \( ng/m^3 \)
- \( C_0 \) = measured background concentration, \( \mu g/m^3 \) or \( ng/m^3 \)
- \( L \) = material loading factor, m\(^2/m^3\)
Loaded test chamber
SPME Holder
Thermal desorption tube
Active sampling
VOC Emission Factors

![Bar chart showing emission factors for various CPSC Material Tracking Numbers.](chart_image)
Carbonyl Emission Factors

Emission factor (µg/m²/h)

CPSC Material Tracking Number

Acetone
Acetaldehyde
Formaldehyde

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SPME Chromatograms

Volatile sulfur compounds

Reactive sulfur gases

Unidentified SPME artifact (see caption)
RSG Emission Factors

Emission factor (µg/m²/h)

CPSC Material Tracking Number

Dimethyl sulfide
Methyl Mercaptan
Sulfur Dioxide
Carbonyl Sulfide
Hydrogen Sulfide

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SO$_2$ SPME Artifact

Calibration gas in air
Calibration gas in N$_2$

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

H$_2$S  Carbonyl sulfide  SO$_2$
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 > CS$_2$

• **SPME fiber passive sampling**
  – Method susceptible to SO2 artifacts
  – Sampling rate dependant on T and RH
  – Requires rapid/consistent transfer from collection to analysis