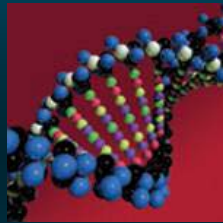


Corrosive Imported Wallboard: Investigating Emissions



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Overview

- Identifying Reduced Sulfur Gas Involvement
- Reduction-Oxidation Chemistry of Sulfur –
only the basics, really...
- Indoor Air Sampling Provided to DOH
- Alternate Sources to Consider
- Emissions and “Cross-Contamination”

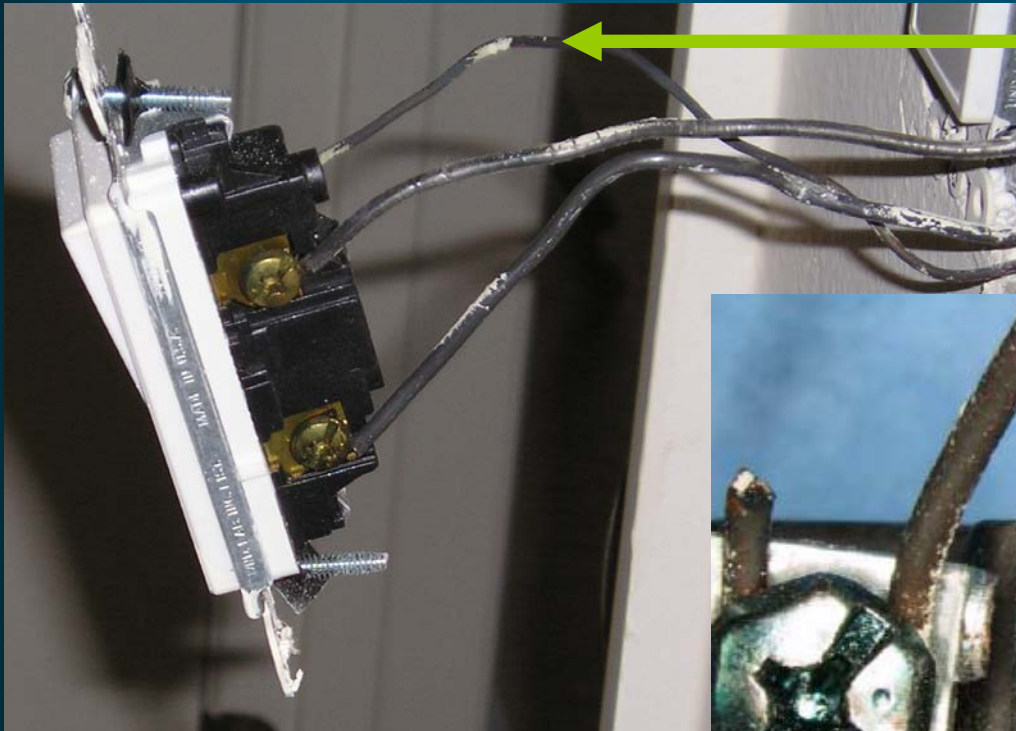


Black, not Blue

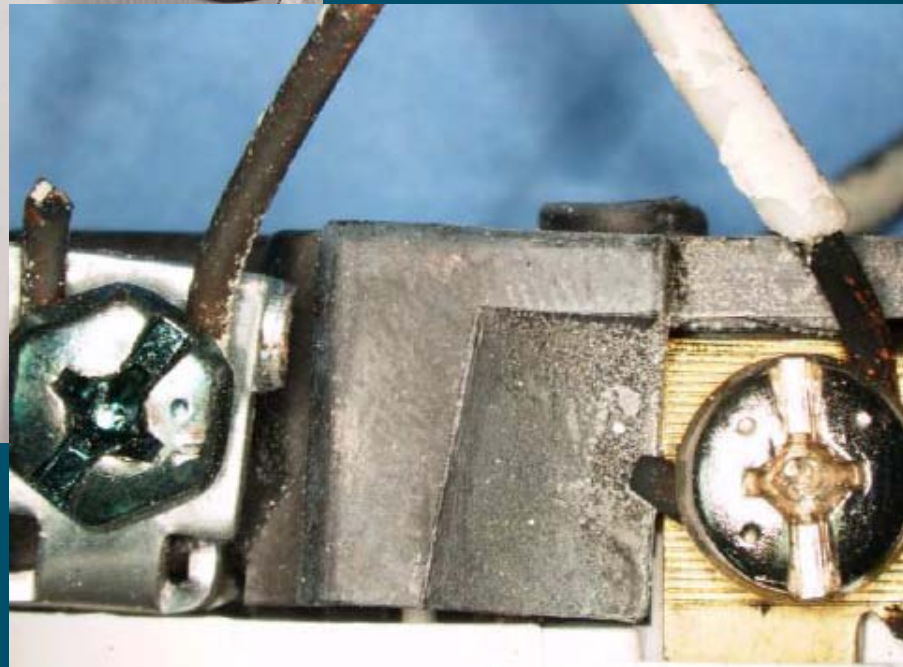
- Corrosion residues are **SULFIDES** (black), not sulfate (greenish blue)
- Hydrogen sulfide (and other sulfides) form corrosive acids themselves
- Importance:
 - Need to focus on remedies that work on sulfide gas releases, not sulfates



Receptacle Showing Residue



Un-insulated
Ground
Conductor





- **Investigations driven unusual rate of HVAC coil failures in S.W. Florida**
- **Smell and characteristic black corrosion of copper due to sulfide (reduced sulfur) gases readily observed**



Trust Your Nose...

- Reduced sulfur compounds have a characteristic type of odor
 - Hydrogen sulfide – rotten eggs
 - Mercaptans – additive to natural gas
- Specific odor in homes is NOT rotten eggs, but definitely “sulfurous”
 - Closest familiar odor – burnt match



Oxidation-Reduction Chemistry

- Refers general to the energetic form of chemicals/reactions
- Reduction – GAIN of electrons (charge)
- Oxidation – LOSS of electrons (charge)
- Getting from one state to the other requires chemical willing to donate or accept charge



It Takes Energy to “Jump the Rail”



**Conversions among chemicals in the same state
“easier” than jumping oxidation states –
specialized conditions/energy required**

Like tends to stay with Like



Sulfides and Sulfates

- **Reduced sulfur compounds**

- **Hydrogen sulfide, carbonyl sulfide, carbon disulfide, dimethyl sulfide**
- **Copper sulfide – black “crust” on copper**

- **Oxidized sulfur compounds**

- **Calcium sulfate (gypsum)**
- **Sulfur dioxide, trioxide (air pollutants)**
- **Copper sulfate – classic greenish copper patina**



Chamber Test of Sulfide Gas Emissions & Corrosion Potential



- Chinese and domestic wallboard placed in sealed jars with:
 - new, clean, polished copper plumbing pipe; and
 - moist sponge (humidity source).
- Gases sampled at week 18.



Reduced Sulfur Gases Found

- Laboratory analysis (ASTM D-5504) showed carbonyl sulfide, carbon disulfide elevated in Chinese board chambers

	Carbonyl Sulfide ($\mu\text{g}/\text{cm}^2$)	Carbon Disulfide ($\mu\text{g}/\text{cm}^2$)
Chinese (n=4)	228	249
Domestic (n=2)	26	58



Indoor Air Sampling

- **Analytical method for air – ASTM D-5504**
 - **most commonly used with part per million sensitivity**
 - **specialty labs with special detectors can reach low part per billion sensitivity**
- **Labs recommend specific brands of sample collection bags (Tedlar bags) for ppb levels – known artifact from one brand**



Reduced Sulfur Time Constraints

- **Reactivity of sulfides requires fast analysis**
 - **24-hr hold time for ASTM-D5504**
 - **Grab samples -- snapshot, but optimize low sensitivity for reactive chemicals – limit degradation**
 - **Summa canisters – concern over reactivity of metal canister, lining integrity**
 - **Challenge for timecourse samples**



Indoor Air Sampling Results

- **Seventy-nine wallboard affected homes sampled**
 - **Two indoor, one outdoor grab samples**
- **Levels frequently below ability to measure, even with sulfur chemiluminescent detector and sub-5 ppb sensitivity.**



Sulfide Gas Levels Detected

- **Carbonyl sulfide**
 - detected in 7 residences
 - avg. = 8.6 ppbv; max = 23 ppbv
- **Carbon disulfide**
 - detected in 20 residences
 - avg. = 7.1 ppbv; max = 13 ppbv
- **No hydrogen sulfide detected**
- **Dimethyl sulfide detected once -- 18.7 ppbv**



Beware Alternate Sources

- **Sulfide gases have affected buildings in certain circumstances before corrosive wallboard emerged**
 - **Mineral rich water**
 - **Sewer connection issues and drain traps**
 - **Wetlands**
 - **Proximity to industrial operations (mostly historic)**
- **Uncommon, but critical to consider – replacing wallboard won't stop problems**



Retention of Emissions in Porous Building Materials

- Questions about wallboard emissions “cross-contaminating” other materials
 - **Non-porous materials – non-issue**
 - **Porous materials – no reservoir, but timing for reversal of any inward diffusion is relevant**
- Diffusion is two-way, equilibration-controlled phenomenon – challenge to model for diverse materials and conditions
- Evaluated by through direct measurement



Wood Sampling Study

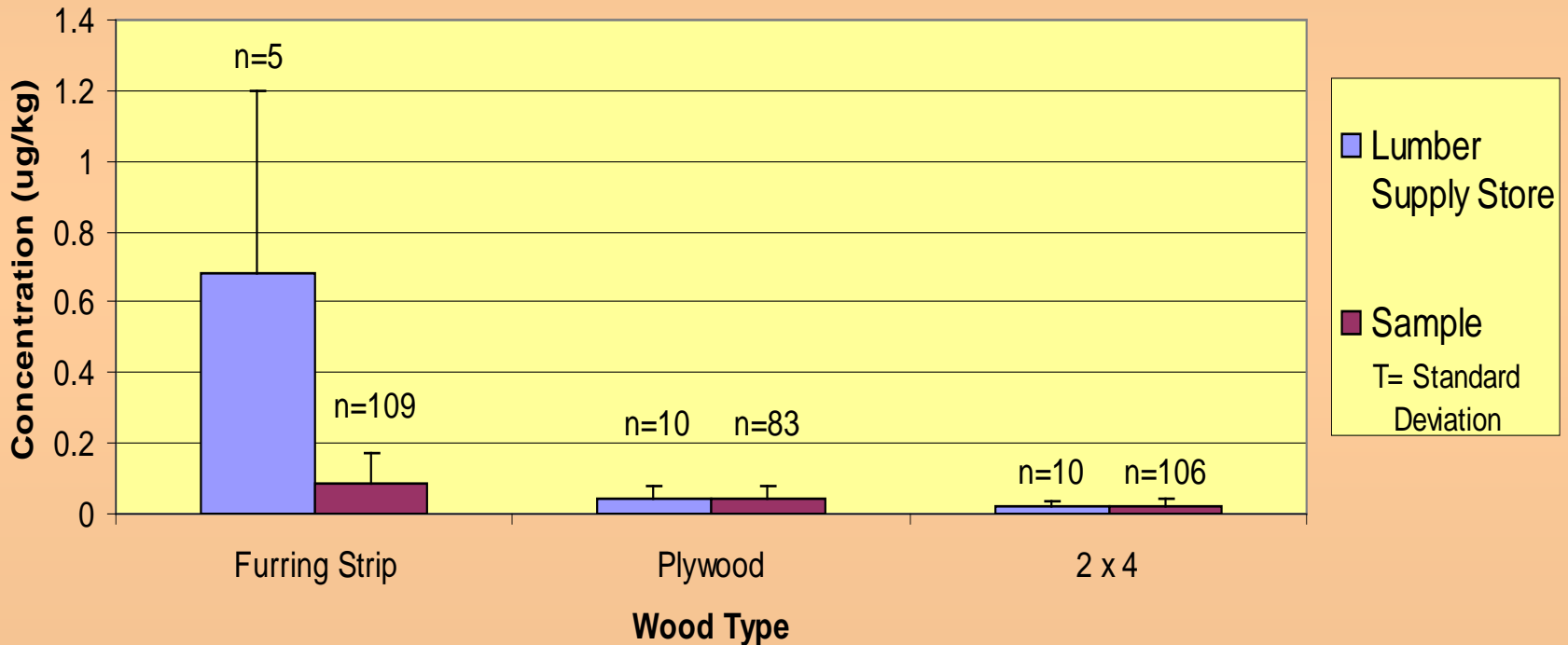
- Plywood, pressure-treated furring strips, framing lumber sampled
 - **54 affected homes under repair, post-ventilation**
 - **2 unaffected homes**
 - **5 retail sources of new materials**
- Sealed in Tedlar bags with 200 ml humidified, zero air
- Equilibrated 24 hrs, 34°C, analyzed ASTM D-5504





Comparison of Wood Types

Average mass of carbonyl sulfide emitted per kg of wood (ug/kg)





Wood Testing Results

- **Carbonyl sulfide frequently detectable in all types of wood products, both in controls and home samples**
- **Carbon disulfide infrequently detected – but similarly low in controls and affected home samples**



Interpretations of Wood Results

- No statistical difference between carbonyl sulfide concentrations in control samples and samples from homes that contained corrosive defective drywall ($p > 0.05$)
- Pressure-treated wood contain highest carbonyl sulfide concentrations
- Number of detected results from unaffected homes was too low for use in statistical comparisons
 - Average detected levels similar to other groups
(Furring Strip = 0.037; Plywood = .072; 2 x 4 = 0.043 $\mu\text{g}/\text{kg}$).



Conclusions from Wood Study

- **New wood products and wood from homes without corrosive imported wallboard contain carbonyl sulfide and carbon disulfide**
 - **Background levels must be taken into account when evaluating materials from wallboard affected homes**
- **Results from 54 homes do not suggest elevated sulfide gas residues from wallboard gas – levels are slightly lower than found in new wood products**



Summary

- *Corrosivity of wallboard emissions due to reduced sulfur compounds*
- *Emissions at very low, ppb levels sufficient to produce corrosion, odors*
- *Analyses are challenging and demand specialized equipment and handling*
- *Cross-contamination – demand controls, residues lost quickly*