

# Corrosive Drywall and other Imported Concerns



## 2013 Annual Georgia Environmental Conference

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# Presentation Outline

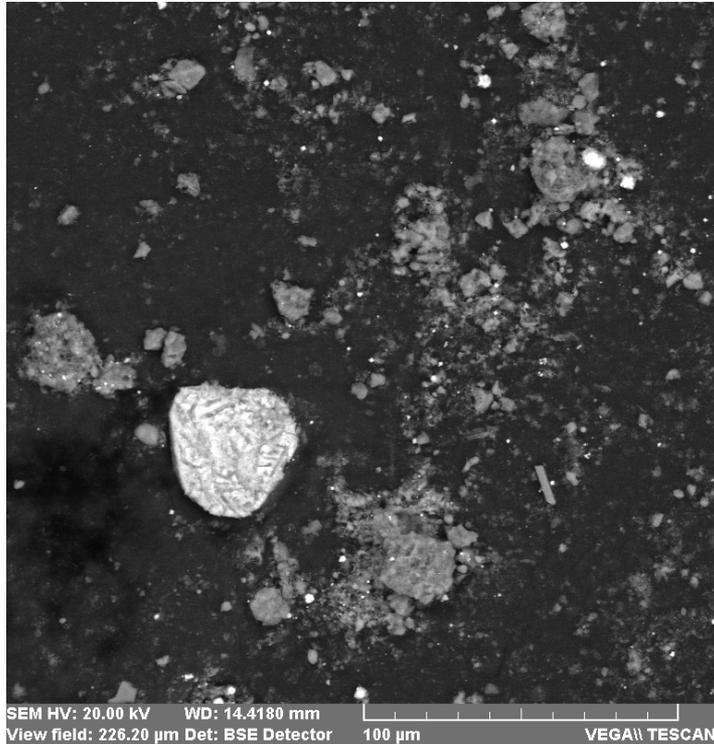
- Elemental sulfur is the distinguishing characteristic of corrosive wallboard.
- Sulfur in the wallboard reacts slowly to release reduced sulfur gases.
- Reduced sulfur gases corrode copper plumbing and electrical components in the home.
- Samples collected from repaired Lucaya residences contained elemental sulfur in wallboard.
- Remediation was required to stop the ongoing corrosion.

# Elemental Sulfur is the Distinguishing Characteristic of Corrosive Wallboard

- Elemental sulfur is a “sensitive and specific marker of problematic drywall” (EH&E, 2010).
  - Strongly associated with hydrogen sulfide emissions and copper corrosion in chamber experiments.
  - Also associated with hydrogen sulfide levels in indoor air and corrosion of silver and copper coupons as part of the CPSC 51-Home study.
- Present as individual particles in the gypsum matrix.
- Likely originated as sulfur inclusions in mined gypsum.

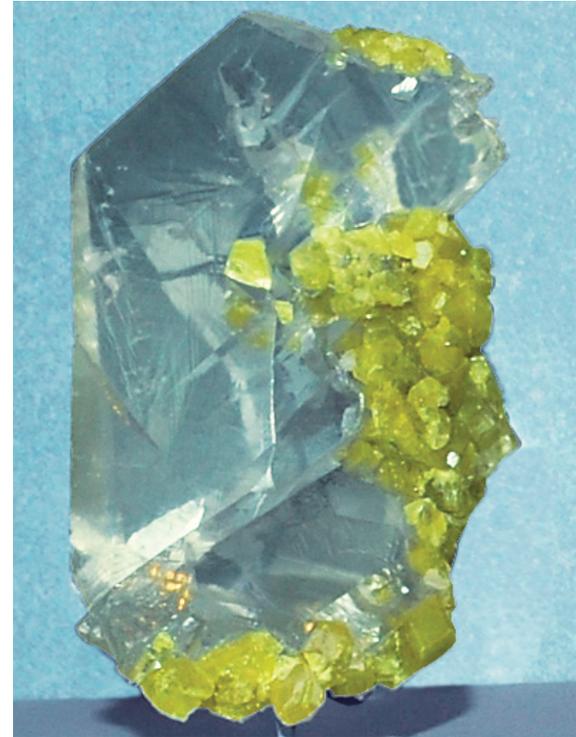
Environmental Health and Engineering, Inc. (EH&E). 2010. Identification of Problematic Drywall: Source Markers and Detection Methods. Prepared for U.S. Consumer Product Safety Commission. EH&E Report 16512. May 28.

# Elemental Sulfur in Gypsum



Scanning electron microscope image of elemental sulfur particle in gypsum wallboard sample.

Source: Materials Analysis Group, Inc.  
Norcross, GA.



Gypsum with sulfur.  
Agrigento, Sicilia, Italy

Source: Smithsonian Institute

# Proposed Reaction Mechanism for Generating Reduced Sulfur Gases

- Carbon monoxide reacts with sulfur to form carbonyl sulfide.



- Carbonyl sulfide hydrolyzes to form hydrogen sulfide.



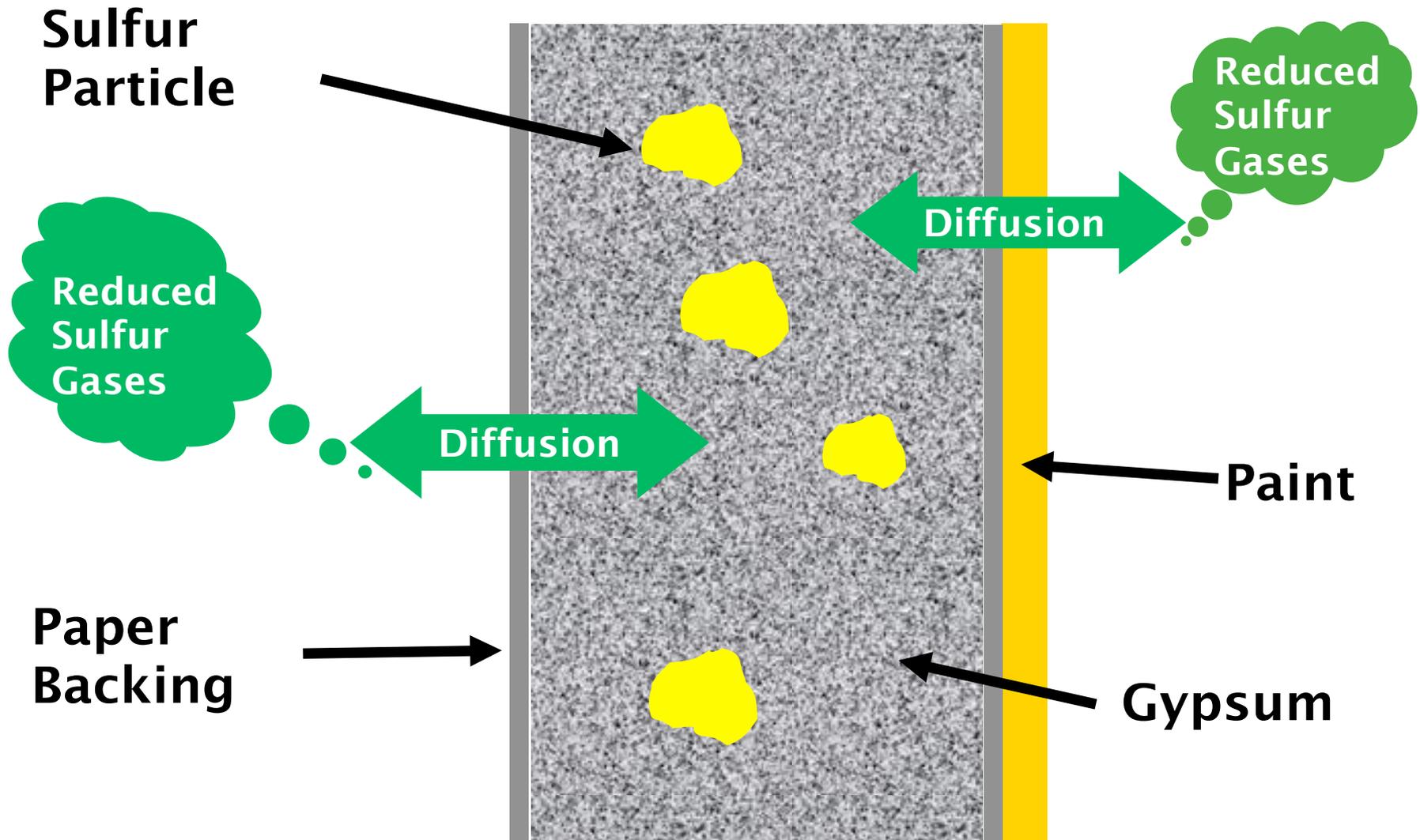
- Competing reaction generates carbon disulfide.



# Proposed Mechanism (cont.)

- Thermodynamically favored.
- Supported by experimental data showing increased OCS with added CO
  - Performed in experimental chambers containing corrosive wallboard.
- Consistent with empirical evidence showing effect of moisture (humidity) on corrosion.
- **Reaction will proceed until sulfur is depleted.**
  - Projected to be on the order of tens to hundreds of years depending on site conditions and level of sulfur in the wallboard.

# Drywall Schematic Illustrating Release of Reduced Sulfur Gases



# Reduced Sulfur Gases Corrode Copper Plumbing and Electrical Components in the Home

- Number of studies have shown that both OCS and H<sub>2</sub>S are corrosive in humid air (e.g. Graedel et al., 1981; Tran et al., 2003).
- **Rate of corrosion is approximately linear with total exposure** (i.e. the product of exposure time and sulfide concentration)(Graedel et al., 1981).
  - Thus, 10 years exposure to 1 ppm produces the same effect as 1 year exposure at 10 ppm.
- Experiments show **corrosion continues even after corrosive wallboard is removed.** (Freeman et al., 2011).

Graedel, T.E., G.W. Kammlott and J.P. Franey. 1981. *Science* 212:663-665.

Tran, T.T.M., C. Fiaud, E.M.M. Sutter, and A. Villanova. 2003. *Corrosion Science* 45: 2787-2802.

Freeman, G.B., R. DeMott, T. Gauthier, M. Stevenson and J. Hubbard. 2011. *J. Fail Anal. And Preven.* 11:265-273

# Rate of Corrosion is Linear with Total Exposure

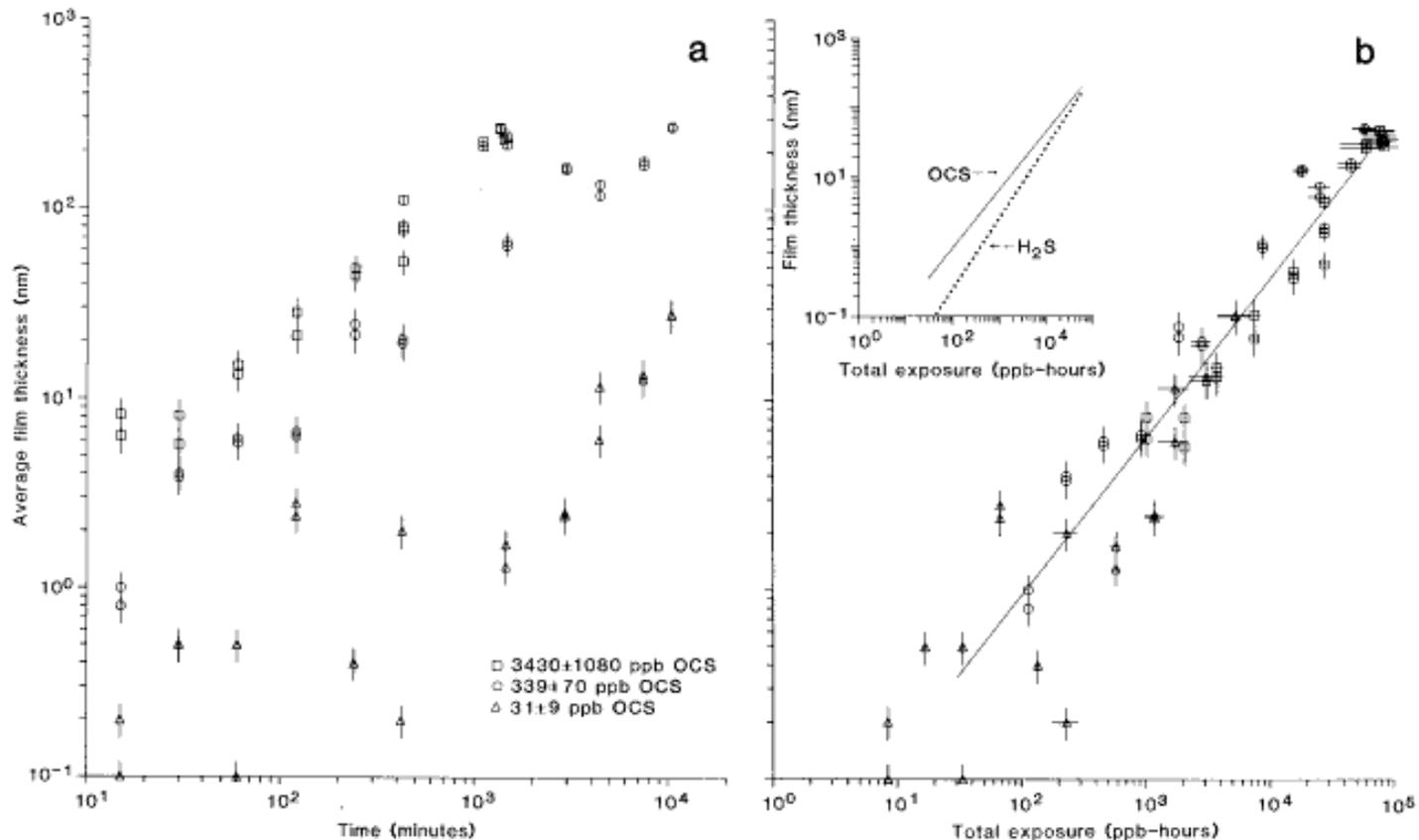
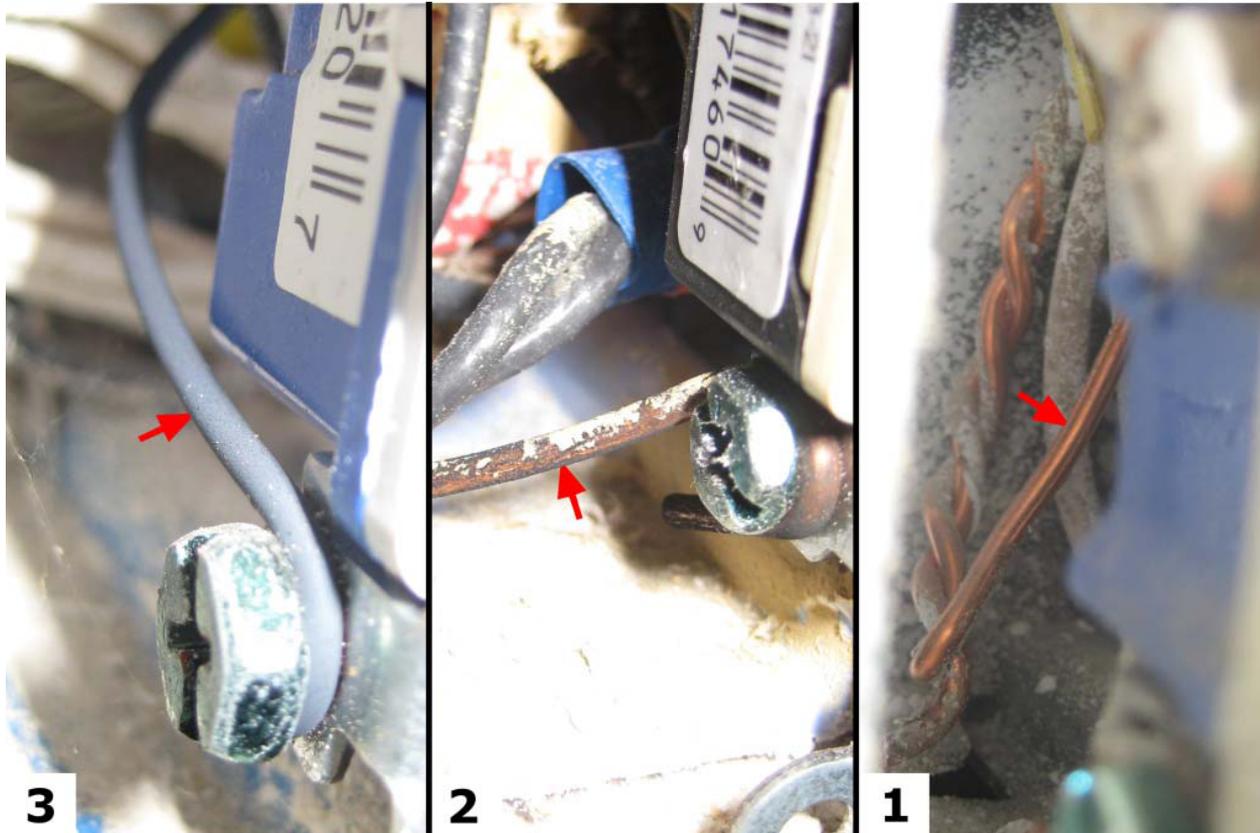


Fig. 1. (a) Sulfide film thickness as a function of exposure time for different OCS concentrations. All exposures were made within the experimental ranges temperature =  $20^\circ \pm 2^\circ\text{C}$  and relative humidity =  $80 \pm 4$  percent. (b) Sulfide film thickness as a function of total exposure to OCS. The solid line is a least-squares fit to the data points. The inset compares the rate of copper corrosion by OCS to that produced by  $H_2S$  exposure, as determined under the same experimental conditions (9).

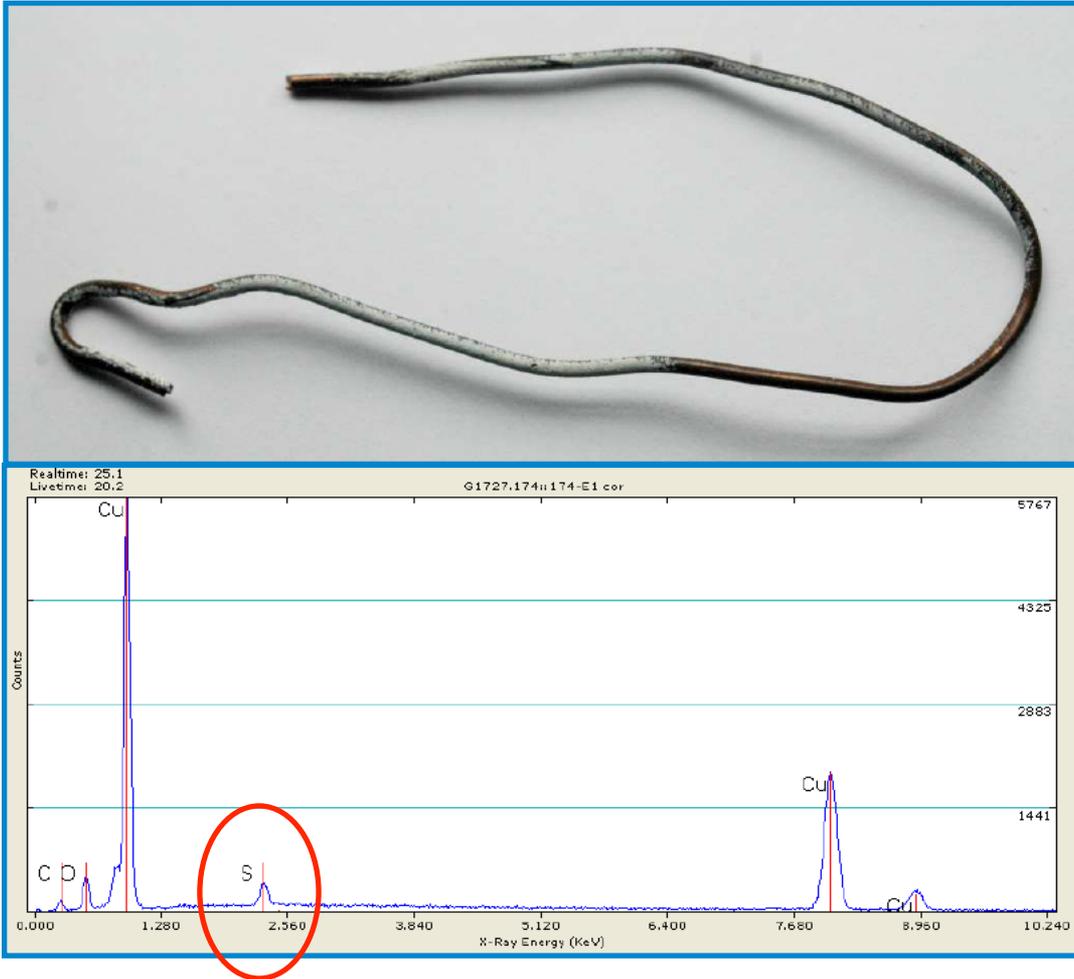
# Visible Corrosion Observed in Most Homes



**Figure 4.1 Example of Visual Corrosion Ratings, Electrical Ground Wire**  
(3—Significant Visible Corrosion, 2—Moderate Visible Corrosion, 1—No Visible Corrosion)

(Source: EH&E, 2010. Final Report on an Indoor Environmental Quality Assessment of Residences Containing Chinese Drywall)

# Sulfur Corrosion Detected on Copper Wire Collected from Residence



“In addition to the paint residue, areas of oxidation and copper oxide/sulfide were present on the surface of this sample. Sulfur was identified as a significant component of some areas of corrosion seen on this sample.”

Materials Analysis Group Inc.,  
Project No. G1727.174, August  
3, 2010

IMT Gypsum detected at 1.5 to 2.5 ppm

# Corrosive Effects Depend on Multiple Factors

- The severity of corrosive effects observed depends upon a number of factors including:
  - Level of sulfur in the wallboard.
  - Percentage of defective wallboard in the home.
  - Ventilation conditions.
    - Air exchange rate in the home.
  - Environmental conditions.
    - Temperature.
    - Humidity.
  - **Exposure Time.**

# Drywall Conclusions (cont.)

- Emissions of reduced sulfur gases will continue until elemental sulfur is depleted.
  - Projected to take tens of years.
- Experiments suggest corrosion of copper will continue even after corrosive drywall is removed.
- Even homes with low sulfur Chinese Drywall (i.e. < 10 ppm) need to be remediated to prevent longer-term corrosion observed in homes built with higher sulfur (> 10ppm) Chinese drywall.

# So Why are We Here and What Have We Learned?

- Between 5-8k homes structures were affected
- Billions spent for repair, litigation and settlement
- Millions of pounds of waste generated
- Not all responsible parties held accountable

Another example of an imported material with unforeseen consequences.

# Other Imported “Mistakes”

- “Samsonite Pulls Luggage Amid Cancer Claims”
  - Elevated PAH’s
- “Rubber on Violin Cases”
  - Tetrachloroethylene
- “The Gingerbread Man”
  - 1,2-Dichloroethane (DCA)
  - [http://www.sciencenews.org/view/generic/id/49897/description/Case\\_of\\_the\\_toxic\\_gingerbread\\_man](http://www.sciencenews.org/view/generic/id/49897/description/Case_of_the_toxic_gingerbread_man)

# Areas of Concern

- Asbestos – 1973 vs. 2013
- Lead
- Mercury – rubber soles of children's shoes
- Melamine – food stuffs for humans and pets
- Chromate – children's toys
- Formaldehyde – engineered building materials, household products
- Antifreeze – toothpaste
- Tires – absent tread separation features
- Seafood – drugs banned by the FDA

# China – Increasing Influence in the Global Marketplace

- 80% of toys sold in US are from China
- Top producer of tires
- Top supplier of seafood worldwide
- More than half of all CPSC recalls are for Chinese manufactured products and nearly all toy recalls are for Chinese manf. toys

# Thoughts for the Future

- What tradeoffs or concessions are we willing to accept for the influx of inexpensive goods?
- The global economy will continue to expand

“Those who cannot remember the past are condemned to repeat it” George Santayana 1863-1952