



# Residential Air Studies and Evaluation of the Potential for Health Effects in Homes with Chinese Drywall

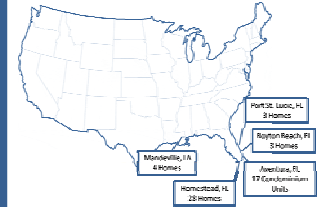
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## Authors

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## Introduction

The Center for Toxicology and Environmental Health, L.L.C. (CTEH) was retained by Knauf Plasterboard Tianjin (KPT) to conduct an independent, third-party indoor air quality investigation of residential units thought to contain drywall manufactured in China.



**Subject Homes:** Units with documented presence of Chinese drywall, reported odors, copper discoloration, and/or HVAC coil discoloration (42 homes).

**Control Homes:** Units without the above conditions (13 homes).

## Methods

### Laboratory Methods

- Aldehydes (NIOSH Method 2016)
  - SKC pumps and Sorbent tubes used to collect 24-hour samples.
- Volatile organic chemicals (USEPA Method TO-15 for VOCs)
  - SUMMA canister 24-hour samples
- Sulfur-containing chemicals (ASTM Method D5504)
  - Tedlar bag grab samples

### Collection Methods

**Initial Sampling**  
SKC pumps and both SKC and Zefon Tedlar bags used for "grab" and 24-hour samples. However, artifact testing showed that SKC pumps and SKC Tedlar bags emitted low levels of carbon disulfide and carbonyl sulfide.

**Subsequent Sampling**  
"Lung" box Zefon Tedlar bags used for "grab" samples  
Only "Lung" box grab samples discussed below  
Tedyne 102E Real Time Continuous Total Reduced Sulfur (TRS)

## Results

### Methyl Mercaptan

- Subject Home Maximum Reading: **10 ppbV**
- Found in 2/42 Subject homes at levels similar to Control homes and Outdoor air
- Used as a food flavoring (WHO Food Additive Series:44, 2000)
- Used as an odorant for LPG, natural gas, and butane (HSDB, 2009)
- Found in human breath: 392 ppb (Suarez et al., 2000)
- Found naturally in sea water and salt water marshes (HSDB, 2009)
- Found in environmental air at levels up to 4 ppbV (ATSDR, 1992)
- Lowest Observable Adverse Effect Level (LOAEL) in animals of 2,000 ppbV (Tansy et al., 1981)
- EPA provisional RIC of 1 ppbV based on animal LOAEL (RAIS, 2009)
- Maximum level in homes is 200 times lower than LOAEL in animals
- American Conference of Governmental Industrial Hygienists average workplace air level limit is 500 ppbV (TLV-TWA) (ACGIH, 2009)
- Levels in homes are not a public health concern

		Subject Homes	Control Homes	Outdoor Air
Methyl Mercaptan (ppbV)	Homes w/detects/Homes tested	2/42	1/13	7/39
	Average* (range)	4.9 (1.6-10)	6.9 (5.2-9.1)	5.5 (1.8-9.6)

\*Average of detections; Detection Limit Range: <0.5 to <5 ppbV

### Sulfur Dioxide

- Subject Home Maximum Reading: **4.0 ppbV**
- Found in 2/18 Subject homes
- Found in 2/12 Outdoor air samples
- Formed when gas or coal is burned
- Released into air from volcanic eruptions (ATSDR, 1998)
- National Ambient Air Quality Standard (NAAQS): 30 ppb (annual average) (USEPA, 2009)
- Maximum indoor air levels well below NAAQS
- Levels do not present a public health concern

		Subject Homes	Control Homes	Outdoor Air
Sulfur Dioxide (ppbV)	Homes w/detects/Homes tested	2/18	0/7	2/12
	Average* (range)	2.4 (1.6-4.0)	<1.0 (<1.0-1.0)	3.1 (2.6-3.7)

\*Average of detections; Detection Limit Range: <1 ppbV

## Abstract

CTEH® performed indoor air quality investigations in residential units thought to contain drywall manufactured in China. Residences were located in five cities in Florida and one city in Louisiana. Units with documented presence of Chinese drywall, reported odors, copper discoloration, and/or HVAC coil discoloration ("Subject") were compared to units without those conditions ("Control"). Outdoor air samples were also collected. Analyses were performed for sulfur-containing chemicals (ASTM D5504 and real-time total reduced sulfur), aldehydes (NIOSH 2016), and volatile organic chemicals (EPA TO-15). Overall, carbonyl sulfide was the most commonly detected sulfide. Carbon disulfide, methyl mercaptan, and sulfur dioxide were detected in a small percentage of Subject homes and in outdoor air. Concentrations were similar in all tested areas. Homes with Chinese drywall generally had total reduced sulfur (TRS) concentrations in the range of 1 to 3 ppbV, whereas locations without Chinese drywall had TRS concentrations in the range of approximately 0.5 – 2 ppbV. Some aldehydes and VOCs were detected at ppb levels in the various units tested. The chemicals detected in these investigations do not pose a public health concern.

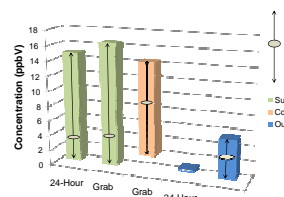
### Carbonyl Sulfide

		Subject Homes	Control Homes	Outdoor Air
Carbonyl Sulfide (ppbV)	Homes w/detects/Homes tested	20/23	5/6	9/27
	Average* (range)	3.0 (0.5-16.6)	8.1 (2.3-14.5)	1.6 (0.5-5.6)

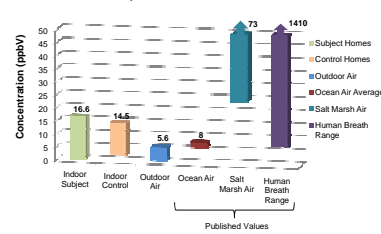
\*Average of detections; Detection Limit Range: <0.5 to <5 ppbV

- Subject Home Maximum Reading **16.6 ppbV**
- Detected in 20/23 Subject homes at levels similar to Control homes
- Present in normal human breath: Average 92 ppbV (range 7.3 to 1410 ppbV) (Sehnert et al., 2002; personal communication with Dr. Risby, 2009)
- Found in ocean air at 6 - 8 ppbV (Kelly, 1990)
- Found in air over salt marshes at 24 - 73 ppbV (Kelly, 1990)
- Occurs in foods such as cheese and grains (Das & Wiener, 1999; Ren and Desmarchelier, 2001)
- There are no regulatory or occupational guidelines established
- Animals have shown **no effect** when exposed to 200,000 to 300,000 ppbV for six hours a day, five days a week for 12 weeks. (Morgan et al. 2004; Bartholomaeus & Hartos, 2005)
- The highest level found in indoor air is hundreds of times below the levels that caused no effect in animals.
- Levels do not pose a public health concern

### Comparison of Indoor Carbonyl Sulfide Concentrations and Outdoor Air



### Carbonyl Sulfide Air Concentrations and Comparison to Published Levels



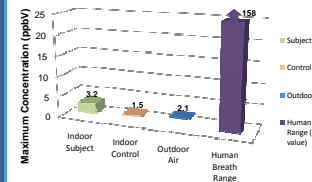
### Carbon Disulfide

		Subject Homes	Control Homes	Outdoor Air
Carbon Disulfide (ppbV)	Homes w/detects/Homes tested	7/42	1/12	1/34
	Average* (range)	1.6 (0.8-3.2)	1.4 (1.3-1.5)	2.1 (2.1-2.1)

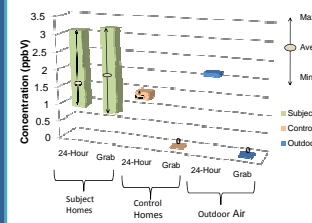
\*Average of detections; Detection Limit Range: <0.5 to <5 ppbV

- Subject Home Maximum Reading: **3.2 ppbV**
- Detected in 7/42 Subject homes
- Measured levels similar in Subject and Control Homes and Outdoor Air
- Released into atmosphere from oceans. (HSDB, 2009)
- Found in normal human breath at an average of 24 ppbV (range 0.24 - 158 ppbV). (Sehnert et al., 2002)
- A concentration of 32 ppbV can be found above new carpeting. (Sollinger et al., 1994)
- Chronic Minimal Risk Level (MRL) = 300 ppbV
- MRL is "an estimate of daily human exposure to a substance that is likely to be without an appreciable risk of adverse effects (noncarcinogenic)" following an exposure lasting a year or longer. (ATSDR, 1996)
- Chronic Reference Concentration (RfC) = 200 ppbV
- Chronic RfC is "an estimate, with uncertainty spanning perhaps an order of magnitude, of a daily [inhalation] exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime" (USEPA, 2009)
- All carbon disulfide levels were well below published health guidelines.
- Levels do not pose a public health hazard.

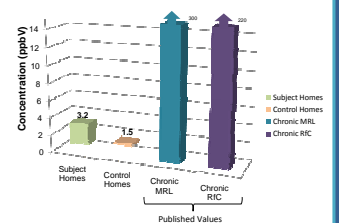
### Carbon Disulfide Air Concentrations and Human Breath Comparison



### Comparison of Indoor Carbon Disulfide Concentrations and Outdoor Air

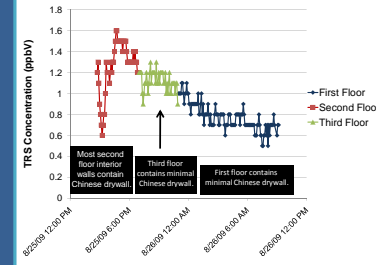


### Carbon Disulfide Levels Compared to Health Guidelines



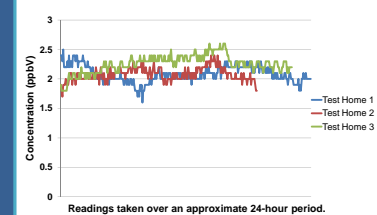
### Total Reduced Sulfur Compounds

#### Three Level Subject Townhouse in Louisiana

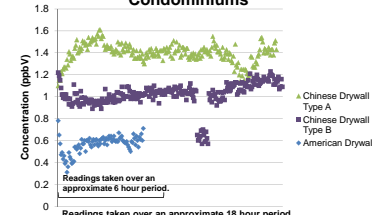


- Maximum level in Subject homes was **4.2 ppbV**
- The Nebraska Department of Environmental Quality TRS standard is 100 ppb as a 30-minute rolling average
- A study of TRS in a community showed no association with respiratory hospital admissions at air levels up to 8 ppb (Luginah et al., 2005)

#### TRS Comparison of Three Test Homes in Port St. Lucie, Florida (all homes contain at least some Chinese drywall)



#### TRS Comparison of Chinese and American Made Drywall in Florida Condominiums



### Hydrogen Sulfide

- Hydrogen sulfide detected in 1/41 Subject homes and 1/13 Control homes above the detection limit range of 1-5 ppbV.
- No connection between Chinese drywall and H<sub>2</sub>S detections
- Naturally found in foods such as beef, onion, cabbage, coffee and chicken
- Found in air above wine at levels up to 14.6 ppbV (Lopez et al., 2007; Fang & Qian, 2005)
- Community evaluations conducted by ATSDR consistently find no public health concern for H<sub>2</sub>S levels ranging up to approximately 20-30 ppbV
- ATSDR minimal Risk Level (MRL) for a 1 year exposure is 20 ppbV (ATSDR, 2006)
- EPA Subchronic RIC (7 year exposure) is 7 ppbV (RAIS, 2009)
- EPA chronic RIC (lifetime exposure) is 1.4 ppbV (USEPA, 2009)
- One hour Ambient Air Guidelines for several states are generally in the 10-30 ppbV range

		Subject Homes	Control Homes	Outdoor Air
Hydrogen Sulfide Detection Limit Range: <1 to <5 ppbV	Homes tested	41	13	-
	Samples taken	126	31	29
	# of detections	1 (4.0 ppbV)	1 (1.7 ppbV)	0

## Conclusions

- Levels of detected sulfur compounds, carbon disulfide, carbonyl sulfide, sulfur dioxide, methyl mercaptan, hydrogen sulfide, and TRS were all below levels associated with health effects.
- Levels of VOCs were also below levels associated with health effects.
- No evidence of a public health concern.