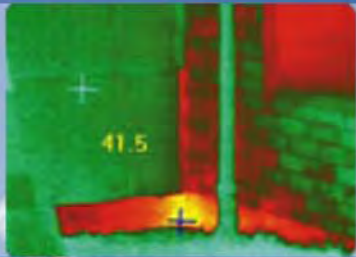


Origin & Implications of Malodorous Gases in Knauf Tianjin Drywall

New Directions in
Sustainable Building Construction
for Architects & Builders



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Certified Mold & Allergen Free Corp.
9-26-09

CPSC July Report

- On page 2 of the CPSC July 2009 Chinese Drywall report they reference an academic research paper that studied Chinese drywall off-gassing.
- This research, done by German scientists, was paid for by the drywall manufacturer Knauf for the stated purpose of understanding where the odors in the Knauf Tianjin drywall came from (either manufacturing or raw mined material) so as to avoid such problem odors in the future.

Page 2 CPSC Report 7-9-09

An academic paper published in 2009 discussed Chinese gypsum and its tendency to emit odors.¹ The authors found that the Chinese gypsum ore and the finished Chinese wallboard were both sources of unpleasant sulfur-like odors. In comparison, non-Chinese samples contained some similar substances, generally at much lower levels, and did not give off the same smell. The authors thought that some of the odor-related compounds might be derived from the raw materials, while others could have been introduced as a result of processing conditions such as crushing and heat. CPSC staff suspected and later confirmed that the Chinese samples used in this study were from the LuNeng mine, located in ShanDong province. In 2006 and earlier, this mine was the sole source of gypsum used by a large manufacturer of plasterboard, which probably manufactured more of the drywall exported to the United States in 2006 than any other company. The academic paper was commissioned by the manufacturer in 2006 when they began to receive complaints of malodorous drywall in Florida.

Presentation Overview

- In this presentation we will review this German study as to the origins of the gases that make the Knauf Tianjin drywall smell.
- This study has important implications as to:
 - The best methods for testing Chinese drywall.
 - The health impact of Chinese drywall.
 - Standards for testing Chinese drywall.
 - And other areas that we will touch on.

Knauf

- Knauf (a German based international company) and the 2nd or 3rd largest drywall manufacturer in the world is the supplier of Knauf Tianjin which is the most prevalent problem Chinese drywall found in US homes.
- Knauf in 2006 hired German researchers to find out what was causing the Chinese drywall they exported to the US to smell.
- In 2009 the results of that research were published.



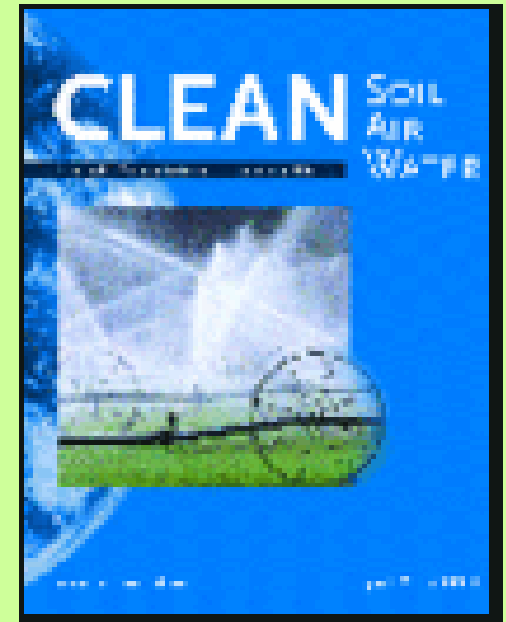
Shandong the location of the LuNeng gypsum mine is located on the East Coast of China

Review of Cited Academic Paper

A. Burdack-Freitag et al.
Institute for Building Physics,
Valley, Germany.

*Identification of Odor-Active
Organic Sulfur Compounds in
Gypsum Products*

Published in the
Wiley InterScience Journal
Clean 2009, 37 (6), 459–465



Gypsum Formation

- The, peer reviewed, scientific paper starts out by describing how Natural Gypsum is formed.
- Natural Gypsum deposits are mainly formed by precipitation of minerals as a result of seawater evaporation in various geological eras when the Earth's surface was dominated by water and marine animals.

Gypsum Formation

- The paper then explains that as a result of how the gypsum deposits are formed the composition of gypsum will differ from location to location.
- According to the report: Typical natural gypsum constituents are lime, marl, clay, bitumen, carbon, pure sulfur or mineral salts and degraded dead marine organisms.
- The degradation of marine organisms plus the formative conditions results in the gypsum containing numerous organic compounds.

Investigation

- The German scientists applied rather sophisticated methods to measure odor levels as well as to quantify the amounts of gases emitted by the Knauf Tianjin drywall.
- They already knew that the drywall gave off inorganic smelly gases such as H₂S and CS₂.
- Their focus was to perform **lab studies (not air sampling)** to characterize smelly gases beyond the known gases which meant looking for sulfur containing organic gases.

Investigation

- Sulfur containing organic gases, as a class of gases, are known to be especially smelly and have a detectable odor at very low concentrations making them difficult to measure.

Technology

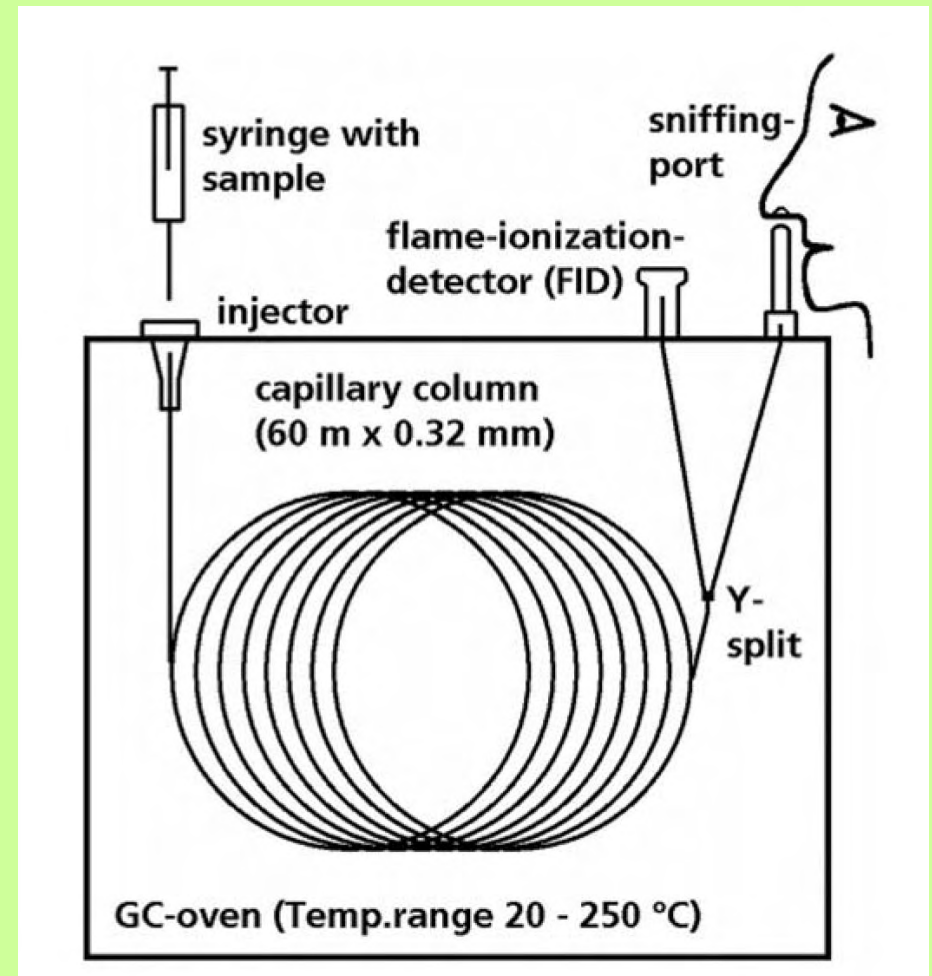
- The German study was based on quantifying the release of organic sulfur gases under **laboratory conditions**.
- They were not taking air samples from homes.
- On the right is shown “headspace” gas measurement equipment the Germans used to measure the quantity of gas emitted from pieces of gypsum in the lab.
- The CPSC calls such studies “chamber” studies.



Figure 1. Sampling of headspace above GyP on a TENAX-TA® tube.

Technology

- Odor levels were also measured using a technique developed by food and perfume chemists.
- On the right is a diagram of the method used to measure the odor levels.



A Challenging Task

- Highly odorous gases (malodorous gases) can be released by problem drywall at very low levels yet still have a perceptible smell.
- Measuring these very low level gases can be a challenge as often the gases are closely related to one another and difficult to distinguish under typical lab testing environments.
- It helps when attempting to measure low levels of gases if you *already know what to look for*.

Measuring Odorous Gases from Raw Material

- For this study the German researchers obtained – in their words “disgusting-smelling semi-processed raw material” from the LuNeng mine in China from which the Knauf Tianjin drywall was made.
- Because the raw gypsum released high levels of smelly gases, it was straightforward for these scientists to determine the types of gases released.
- Once they knew what to look for, they were able to more easily measure the much lower levels of odorous gases released by the actual Knauf Tianjin drywall. Pretty smart!



Trucks taking Chinese drywall to the docks for shipment to the U.S.

German Lab Study Results

- While the drywall released many organic gases, the researchers were focusing on especially smelly gases which means sulfur containing organic gases.
- They were able to identify 8 odor-active sulfur containing organic compounds released by the drywall.
- This was in addition to the smelly inorganic H₂S and CS₂ gases that were already known to be present.



Chinese ship being loaded with drywall for shipment to the U.S.

German Lab Study Results

- The eight sulfur-containing organic compounds contributing to the off-odor of Chinese drywall were identified as:
 - 2-(ethylthio)-propane,
 - methyl ethyl disulfide,
 - butyl ethyl sulfide,
 - ethyl isopropyl disulfide,
 - diisopropyl disulfide,
 - isobutyl isopropyl disulfide,
 - diethylthiophene, and
 - ethyl isopentyl disulfide

German Lab Study Results

- These results from the German lab studies have important implications.
 - Why – because these organic compounds have high odor levels and are not corrosive nor irritating (at least to the same degree as the inorganic gases H₂S and CS₂.)
 - This may account for the reason why some homes with Knauf Tianjin drywall smell but do not tarnish copper and do not irritate occupants.



German Lab Study Results

- These results have important implications for future research.
- Why, because these studies mean there are other gases being emitted by the Knauf Tianjin drywall and not just the inorganic gases H₂S, CS₂, and COS that are commonly discussed.
- The organic gases also need to be studied.

Centek Laboratories, LLC				Date: 23-Jun-09		
CLIENT:	Ceritified Mold & Allergen Free Corp	Client Sample ID: Knauf (Metric writing - Not regular Knauf)				
Lab Order:	C0906023	Tag Number:				
Project:	Headspace	Collection Date: 6/5/2009				
Lab ID:	C0906023-001A	Matrix:				
Analyses	Result	**Limit	Qual	Units	DF	Date Analyzed
LOW LEVEL SULFURS BY TO-15		TO-15		Analyst: LL		
Carbon disulfide	11000	20	E	ppbV	4	6/17/2009 9:42:00 PM
Carbonyl sulfide	970	20		ppbV	4	6/17/2009 9:42:00 PM
Hydrogen Sulfide	690	20		ppbV	4	6/17/2009 9:42:00 PM
Surr: Bromofluorobenzene	96.8	70-130		%REC	1	6/17/2009 8:58:00 PM
NOTES:						
E - Estimated value. The amount exceeds the linear working range of the instrument.						

Comparing Other Published Lab Tests

- Unified Engineering under contract from the State of FLA had performed a study (File #4050) of gases released from Knauf drywall also under laboratory conditions.
- Their report stated that although the Knauf drywall did smell they actually measured lower levels of sulfur gases emitted from the Knauf material than from the US drywall that had no smell. That makes no sense.
- So the fact that Unified Engineering stated that they did not find any of the organic sulfur gases that the German scientists found does not in any way contradict the, what would appear to be, excellent work of the German group.

Potential Problems from Lab Studies

- There are several potential problems from lab studies of drywall:
 - Results differ from lab to lab because procedures and equipment differ.
 - In lab testing, the temperature and humidity are typically set high which increases the rate of off-gassing. Drywall can be then checked quickly and inexpensively for emitted gases.
 - Given enough temperature and humidity, off-gassing is measurable from ALL drywall (even top quality US drywall) to some extent.

Potential Problems from Lab Studies

- Lab studies give you some idea of the possible mix of gases being given off by the problem drywall but in no way indicate the levels present in the real world (home or office environment.)
- **Only air sampling can do that.**

CPSC Gas Testing in Progress

- The CPSC has awarded a contract to Lawrence Berkeley National Laboratory in June 2009 for lab studies – analysis of gases released by pieces of drywall under lab conditions.
- This lab is not available for the public to use.
- Along with the actual results, the CPSC must provide guidelines (temperature and humidity etc) for such tests so that when the public sends samples to other labs (Lakeland, Centek, etc) the results from those labs can be compared to the results from the Lawrence Berkeley National Lab.



Drawing the **WRONG** Interpretations from Lab Studies

- Even though a certain brand of drywall does not smell, does not corrode copper and does not damage the AC coils – if it is stamped “China” on the back, some inexperienced environmental consultants are claiming it is defective because testing **under lab conditions** finds some off gassing.
- **Note that the State of Florida DOH guidelines do not recognize drywall meeting these criteria as defective.**

CPSC: Not All Chinese Drywall Defective

- On Sept 22, 2009 Inez Tenenbaum head of the US CPSC stated:

“wallboard comes from several Chinese manufacturers, the drywall is not all made the same way and some Chinese drywall does not cause problems”.

Lab Studies vs. Air Sampling

- So what do all these lab tests actually tell us about the real world?
- From a certain perspective they may mean nothing.
- Lab studies (also called Chamber testing or Headspace testing) in no way measure the levels of such gases found inside homes.
- To measure the levels of emitted gases inside a home or office one must perform **air sampling**.



Example of stainless steel container used for air sampling..

Knauf Air Sampling

- Knauf actually had the environmental company CTEH do some limited air sampling studies back in 2006 which was the same year Knauf hired the German lab to start the research on Knauf Tianjin odor.
- **Carbonyl sulfide and carbon disulfide were found in homes that were tested by air sampling.**



Center for Toxicology and Environmental Health, L.L.C.

615 W. Markham Street Little Rock, AR 72201 Phone: 501.614.2834 Fax: 501.614.2835 www.cteh.com

Summary of Air Sampling Results November 29, 2006

Summary

In response to reports of sulfur-like odors potentially associated with the use of Knauf Tianjin gypsum plasterboard, the Center for Toxicology and Environmental Health, L.L.C. (CTEH) was mobilized to the Miami-Ft. Lauderdale, Florida area to conduct an air quality investigation. CTEH performed air quality testing for a wide variety of chemicals, including sulfur-containing compounds and volatile organic compounds (VOC). The testing results were evaluated to determine if the measured compounds posed an unacceptable public health risk.

Environ Air Sampling

- Again, CTEH under contract with Knauf in 2006 did find elevated sulfur gases in the living space of homes they tested.
- On the other hand Environ under contract to Lennar, according to published statements from Lennar, has never found elevated levels of sulfur gases in Lennar homes full of smelly Knauf Tianjin drywall.
- The contradictory findings would **appear to** make no sense.

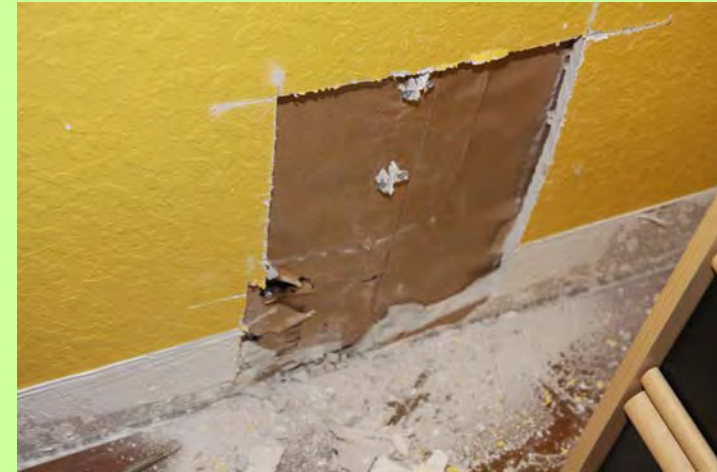


Air Sampling & Temp/Humidity

- Just as under lab conditions, temperature and humidity levels greatly affect sulfur gas emission...
- Temperature and humidity of homes during **air sampling** and also the days just before the sampling have a **huge impact** on the levels of Chinese drywall gases released ... and therefore collected.
- Hot and humid homes have higher levels of Chinese drywall gases.
- During cooler winter months or with the AC turned way down – the smell (off-gassing) goes way down or may even be non-existent.

Air Sampling Tricks

- We have been told that some environmental companies working for builders call the homeowners before air sampling and ask them to turn down the AC before they will start the testing.
- This greatly lowers sulfur gas emissions.
- Perhaps this trick is the reason that some companies never find any sulfur gases in homes full of smelly sulfur gases?
- *Note: Our firm and others do find elevated levels of sulfur gas in homes that smell from Chinese drywall. We find this under normal, not over cooled, living conditions.*



Checking drywall for the printed manufacture name.

Summary & Conclusions

- Knauf Tianjin drywall releases organic gases in addition to the inorganic H₂S, CS₂, COS gases commonly discussed.
- Most government studies are focusing on the inorganic gases.
- Organic gases released by Chinese drywall also need attention.

Summary & Conclusions

- The rate of gas release is highly dependent on the temperature and humidity of the test environment.
- This will be the case for both lab studies and air sampling inside of homes.
- We need **test standards** that deal with such matters so that results from different labs can be compared.

Summary & Conclusions

- Some of the organic gases released by Chinese drywall have high odor levels and are not corrosive nor irritating (at least to the same degree as the inorganic gases H₂S and CS₂.)
- This may account for the reason why some homes with Knauf Tianjin smell but do not tarnish copper and do not irritate occupants.
- This has implications to the extent Chinese drywall affects the health of occupants.

Summary & Conclusions

- All brands of drywall will release some level of gases under lab conditions.
- But a lab test does not represent living or working conditions in a home or office.
- Lab testing (also called chamber testing or headspace testing) that finds elevated gas released from drywall is **NOT SUFFICIENT** for determining that there is problem Chinese drywall.

Summary & Conclusions

- The State of Florida DOH does not recognize this form of testing.
- What they recognize is that homes with problem drywall smell, have corroded copper and often have problems with the AC coils.
- Measuring the release of sulfur gases under laboratory conditions can be a useful tool (in the hands of professionals) but ONLY when used in CONJUNCTION with the guidelines established by the DOH.

We Can Hypothesize

- From the German research we know:
 - The raw mined material used to make the Knauf Tianjin smelled.
 - Therefore the drywall that was shipped to this country smelled.
 - And the drywall that was sitting in the distributor's warehouse smelled.
 - And the drywall that was installed in homes smelled.
 - Given that remediation workers are getting sick (or irritated) from working in homes during drywall removal, **it may be** ... that workers doing the original installation were also being affected by the fumes.

Important Questions NOT Yet Answered

If drywall contractors were getting sick during the installation, did builders actually know of the problem during the construction?

Important Questions NOT Yet Answered

At some point in 2006 builders refused to allow Chinese drywall to be used in any new construction.

At what point (if ever) did builders know that homes **being sold** were defective?

Tricks Being Played

- Drywall shipments that arrived in the cooler / drywall months would not appear problematic because low temperature and humidity mask the problem.
- During warmer & more humid conditions the homes will start to smell and homes that smell do not sell.
- **How could these smelly homes be sold?**
- Some consultants have been using tricks ... setting the AC thermostats way down before air sampling so that the lower temperature hides the smell.

Important Questions NOT Yet Answered

Was the same trick, turning the AC way down, used to mask the Chinese drywall smell in new homes for sale... in order to get people to buy homes with known defective drywall?

About Certified Mold & Allergen Free Corp.

- Related to Chinese drywall, we:
 - Test homes and offices for the presence and extent of Chinese drywall.
 - Provide air sampling services, in conjunction with Centek Labs, to home owners and builders.
 - Provide remediation consulting support to builders and developers.
 - Provide expert services.