DRAFT REPORT ON PRELIMINARY MICROBIOLOGICAL ASSESSMENT OF CHINESE DRYWALL

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LIST OF ABBREVIATIONS AND ACRONYMS

CPSC	U.S. Consumer Product Safety Commission
EH&E	Environmental Health & Engineering, Inc.
H_2S	hydrogen sulfide
MPN	Most Probable Number
PCR	polymerase chain reaction
SRB	sulfate-reducing bacteria
°C	degrees Celsius

1.0 EXECUTIVE SUMMARY

Environmental Health & Engineering, Inc. (EH&E) presents this preliminary report to the U.S. Consumer Product Safety Commission (CPSC) regarding the microbiological assessment of ten samples of drywall. This study was conducted to provide information on the presence of sulfate-reducing bacteria (SRB) in the drywall system that may be linked to the odors attributed to the material imported from China. Additionally, this report includes a brief discussion of the peer-reviewed scientific literature as well as presentations on microbiological contamination of drywall delivered at the Technical Symposium on Corrosive Imported Drywall held on November 5-6, 2009, in Tampa, Florida. EH&E's evaluation was initiated on Friday, October 30, 2009, and consisted of specifying drywall sampling and microbiological assessment procedures, selecting drywall samples from those previously submitted from CPSC and dispatching them to the microbiological testing laboratory for culture and analysis.

Detailed explanations of all methods, results, and discussion are included in the body of the report. The findings of this evaluation indicate that the presence of SRB was confirmed in one of four gypsum cores taken from imported drywall samples and in one of the six gypsum cores taken from domestic drywall samples. The presence of SRB was not detected in any of the microbiological tests conducted on extracts of the paper facing (front) or paper liner (back) of the drywall samples. This preliminary study demonstrates that SRB is culturable from a subset of both Chinese and U.S. manufactured drywall samples, but does not definitively determine if microorganisms are responsible (wholly or in part) for the generation of corrosive gases generated from problem drywall.

2.0 BACKGROUND

2.1 INTRODUCTION

This report was prepared on behalf of the CPSC by EH&E and describes a preliminary study on the evaluation of selected microbiological agents purported to be present in drywall imported from China. Specifically, the evaluation involved the culturing of drywall samples for bacteria known as the class of "sulfate-reducing bacteria (SRB)."

2.2 BIOLOGY OF SULFATE-REDUCING BACTERIA AND MICROENVIRONMENTS

SRB are considered to be of interest in the investigation of problem drywall due to the observation of "rotten egg"-like odors from the material itself as well as the odor being present inside the homes in which the problem drywall is installed. These "rotten egg"-like odors are often associated with sulfur-based gases including hydrogen sulfide (H_2S). H_2S has been generated from problem drywall by SRB under anaerobic laboratory test conditions (Bergersen and Haarstad 2008). H_2S has also been shown to be released from the anaerobic decomposition of calcium sulfate in drywall at construction-waste landfills (Fairweather and Barlaz 1998; Gypsum Association 1992).

SRB are a group of microorganisms that typically exist in anaerobic environments, that is, environments without free oxygen. SRB utilize compounds other than oxygen for supporting respiration and producing usable energy in order to maintain intracellular biological processes. SRB reduce sulfur-based compounds such as sulfate, sulfite, thiosulfate, and sulfur, to sulfide. During their growth, SRB produce sufficient H_2S that assures the maintenance of anaerobiosis. The "rotten egg" odor is characteristic of these active biological processes.

In order for SRB to thrive, continuous sources of both organic material and sulfate ions must be available. A simplified formula of H_2S generation is listed in Figure 2.1.

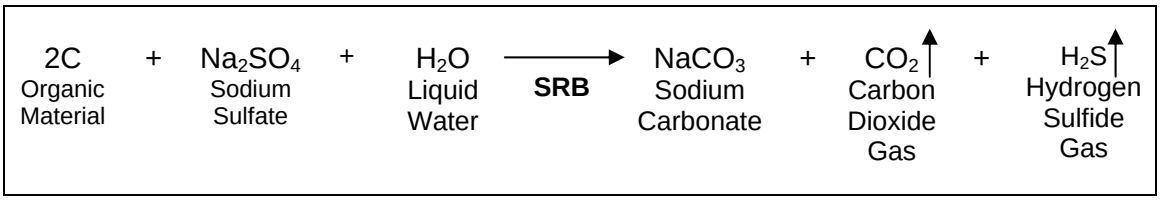

Figure 2.1 Action of Sulfate Reducing Bacteria to Produce Hydrogen Sulfate Gas

H_2S gas can be generated only when all of the following conditions exist:

1. Presence of liquid water
2. Organic material available (i.e., carbon source)
3. Sulfate ions available
4. Absence of air
5. Presence of sulfate-reducing bacteria
6. pH level of 4.0 – 9.0
7. Optimal temperature range (30 – 38 degrees Celsius [°C])

Typical environments in nature that support SRB growth include landfills, bogs, and deep water caverns where oxygen depletion exists. In the built environment, SRB organisms are present in biofilms in plumbing and sewer systems. Although this could be considered a macro aerobic environment, the SRB grow in a micro-environment under the slime layer next to a substrate where oxygen levels are depleted. SRB growth along these surfaces results in considerable corrosion to the metal piping and is at the center of an active industry effort for corrosion control.

3.0 DRYWALL SAMPLING AND LABORATORY ANALYSIS

3.1 DRYWALL SAMPLING

On Friday, October 30, 2009, a subset of ten drywall samples was assembled from the CPSC-supplied set of drywall samples with known origins identified as "catalog samples," as shown in Table 3.1. This catalog subset was dispatched to EMLab P&K (San Bruno, California) for evaluation of the presence of SRB.

Table 3.1 Drywall Samples Selected for Microbiological Assessment from U.S. Consumer Product Safety Commission Supplied Drywall Sample Set

EH&E Sample ID	CPSC Sample Designation	Reported Origin
CH-4	CH-4 7339-02	China
CH-5	CH-5 8357-02	China
CPSC3	CPSC3 09-302-1379-02	China
CPSC4	CPSC4 09-840-9858	United States
CPSC6	CPSC 09-810-7639-06	United States
CPSC7	CPSC 09-840-9961-03	United States
CPSC8	CPSC 09-840-9962-08	United States
CPSC9	CPSC-09-810-8213-02	United States
CPSC10	CPSC 09-810-7069-06	China
CPSC13	CPSC 09-810-8037-01	United States

EH&E Environmental Health & Engineering, Inc.
CPSC U.S. Consumer Product Safety Commission

3.2 LABORATORY TESTING FOR SULFATE-REDUCING BACTERIA

Following receipt at the EMLab P&K microbiology laboratory, the ten samples were processed for testing by removing the face paper on the front side and the liner paper on the back side of the gypsum core. These individual papers, each measuring 1" x 1", were processed by wetting the paper with water and preparing a 1:100 dilution of the extract solution for culture. The gypsum cores were processed for testing by removing the paper on each side and then pulverizing and wetting the sample. A 1:10 dilution of the extract solution was used for the gypsum core samples.

Culture was performed by the Most Probable Number (MPN) technique in a modification of Method 9240 Iron and Sulfur Bacteria as published in *Standard Methods for the*

Examination of Water and Wastewaters, 20th Edition, 1998 (SM 1998). The samples were inoculated into tubes which were filled completely with sulfate-reducing medium to create anaerobic conditions with a pH of 7.5 and incubated for 21 days at 30 °C, as per the standard method. After incubation, the samples were checked for bacterial growth as evidenced by blackening of the media. Uninoculated tubes were incubated with the sample tubes as controls. The reported detection limit was less than 3.1 colonies by MPN per paper sample and 0.31 colonies per gypsum core sample.

3.3 RESULTS

EMLab P&K reported that SRB growth was detected on one of the four gypsum core samples with Chinese origin and one of the six gypsum core samples of domestic origin had growth. Growth was not detected on any of the twenty paper samples cultured from the ten drywall samples under analysis (see Table 3.2).

Table 3.2 Microbiological Results of Drywall Samples Analyzed for Sulfate-Reducing Bacteria

	Sulfate-Reducing Bacteria (MPN/unit*)		
EH&E Sample ID	**Face Paper (front)**	**Liner Paper (back)**	**Gypsum Core (LCL, UCL)**
CH-4	ND	ND	0.31 (0.04, 2.2)
CH-5	ND	ND	ND
CPSC3	ND	ND	ND
CPSC4	ND	ND	0.97 (0.23, 4.1)
CPSC6	ND	ND	ND
CPSC7	ND	ND	ND
CPSC8	ND	ND	ND
CPSC9	ND	ND	ND
CPSC10	ND	ND	ND
CPSC13	ND	ND	ND

MPN Most Probable Number
EH&E Environmental Health & Engineering, Inc.
LCL lower 95% confidence limit
UCL upper 95% confidence limit
ND none detected

* The detection limit for the MPN technique is less than 3.1 bacteria per paper sample and 0.31 bacteria per sample for gypsum core sample.

Method: Most Probable Number (MPN) using modified Standard Methods 9240.

4.0 DISCUSSION

In this preliminary assessment, SRB was cultured from one of the four drywall core samples from China and one of the six core samples that originated in the United States. While the presence of SRB in a subset of drywall samples has been confirmed, additional testing is required to evaluate the true import of SRB's involvement in the generation of H_2S in indoor environments. The presence of SRB in cultured samples does not necessitate drawing the conclusion that these bacteria were metabolically active and necessarily responsible for the generation of H_2S indoors because of the dramatic differences between the environmental conditions present during the culture period (e.g., anaerobic conditions, soluble sulfate, and elevated temperature) and the conditions typically present within homes. Furthermore, since there are both spore forming and non-spore forming strains of SRBs, the culturing of low levels of SRB under laboratory conditions may reflect the fact that they are artifacts of the manufacturing process and does not necessarily indicate that the SRB are metabolically active during the period of the subject drywall installation in the home and capable of metabolizing elemental sulfur to H_2S.

While several organizations have hypothesized that SRB is responsible for production of reduced sulfur gases, only one peer-reviewed scientific paper was identified on this topic and it did not show a positive association between SRB and problem drywall. In the study published in 2010, subsequent to a poster in 2009, Hooper and colleagues describe the isolation of an iron oxidizing bacterium, *Thiobacillus ferrooxidans*, in Chinese drywall using a real-time polymerase chain reaction (RT-PCR) methodology (Hooper et al. 2010).

T. ferrooxidans is not considered a SRB, and is, in fact, a well-documented oxidizer of reduced sulfur compounds (Janiczek et al. 1998). However, a possible mechanism by which *T. ferrooxidans* can generate H_2S has been described in the peer-reviewed scientific literature (Sugio et al. 1992). *T. ferrooxidans* is found naturally in acid mine drainage waters of iron and coal mines and typically utilizes iron sulfide, also known as pyrite, as a substrate (Rojas-Chappana et al. 1996). Pyrite has recently been identified in corrosive imported, domestic, and domestic–synthetic drywall (DeMott et al. 2009).

T. ferrooxidans optimally grows at pH levels between 2.0 and 2.3 (Jensen and Webb 1995). In a study conducted by the U.S. Environmental Protection Agency, the pH of six drywall samples (5% slurry) ranged from 7.08 to 7.41, indicating the drywall is not likely to be an environment conducive to the growth of *T. ferrooxidans* (EPA 2009). Additionally, due, in part, to the low pH and aerobic growth requirements, *T. ferrooxidans* would not be detected in the SM 9240D culturing methodology employed by EMLab P&K in this study.

Other groups, in non-peer reviewed literature, have also evaluated the role of SRB as a source of sulfur gases generated from problem drywall. In the October 2, 2009, issue of Builder Magazine, an interview with Sabre Technical Services advanced the position that the paper facing in problem drywall contains bacteria that are capable of producing reduced sulfur gases. This position is contradicted by a limited study in which gamma irradiation was used to sterilize one piece of problem drywall and to examine the effects on corrosion potential. The study concluded that irradiation did not alter the corrosion potential of the drywall and, therefore, live bacteria did not play a role in copper corrosion (Cerro 2009).

In conclusion, there are conflicted studies of varying quality that have attempted to determine the role, if any, of microorganisms in the generation of sulfur-based corrosive gases emanating from problem drywall. This preliminary study demonstrates that SRB is culturable from a subset of both Chinese and U.S. manufactured drywall samples, but does not definitively determine if microorganisms are responsible (wholly or in part) for the generation of corrosive gases generated from problem drywall.

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