Microbial Resistant Gypsum Products

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Abstract

Gypsum building materials often become wet, resulting in mold growth that leads to health and productivity impacts, as well as to liability and lawsuits. A major source for mold growth in schools, homes, and the work place is gypsum wallboard since nearly 90% of the interior finished surfaces of buildings are covered with gypsum products. It has been estimated that upwards of 40% of all homes in North America contain fungal growth on gypsum wallboard. The rapid growth and dispersion of mold can induce allergy and asthma episodes, and sometimes produces severe illnesses including pulmonary, immunologic, neurologic and oncogenic disorders. Removal of growth substrates from building materials, or the incorporation of antimicrobial agents in the manufacturing of building products may prevent mold growth and the spread of biological contaminants. There are several gypsum products readily available that can reduce mold growth in the indoor environment. However, there is no nationally accepted testing and verification program to guide consumers and building professionals on how to select or specify the best gypsum products for their needs. This talk will focus on the development of standardized testing methods and subsequent product verification through the EPA's Environmental Technology Verification – Environmental and Sustainable Technology Evaluation (ETV-ESTE) program.

Environmental Technology Verification

The Environmental Technology Verification (ETV) program was initiated by the Environmental Protection Agency (EPA) in October, 1995. This program was set up to provide credible performance information for commercial-ready technologies to help solve high risk environmental problems. Using this overarching framework, the program aids policymakers and regulators in policy and permitting decisions for innovative technologies, purchasers in making decisions to purchase innovative technologies, and vendors/developers in selling and further innovating technologies. ETV seeks to establish or confirm the performance of a technology under specific, predetermined criteria or protocols and adequate QA procedures; however ETV does not pass / fail, approve, or certify technologies. To date there have been 330 verifications utilizing 84 different protocols.

In 2005 a new program was initiated under ETV entitled Environmental and Sustainable Technology Evaluation (ESTE). ESTE is targeted to critical agency needs, where the EPA chooses the technology categories to verify, and initiates and directly manages these verifications. ESTE projects are scoped to include all environmental technologies, except remediation.

ETV-ESTE maintains a core set of values that are important to every verification project. The first core value is quality whereby a strong quality assurance (QA) system is in place for each project. ETV follows ANSI E4 standards for environmental technology evaluation. Quality planning and implementation involve development of a program Quality Management Plan (QMP), center-specific QMPs, test-specific Quality Assurance Project Plans (test plans), and reviews and audits by EPA and center QA staff.

In a recent review of ETV, the Science Advisory Board commended ETV for its QA procedures and their implementation. The second core value is transparency within the system. This is carried out by publicizing all test plans and verification results. The third core value is fairness. All vendors are contacted and invited to take part in the verification process. The fourth core value is credibility which is achieved by meeting the previous three core values.

Fungal Growth in the Indoor Environment

According to the Lawrence Berkeley National Laboratories, improving buildings and indoor environments could reduce healthcare costs and sick leave and improve worker performance, resulting in an estimated productivity gain of $30 billion to $150 billion annually (1). The DOE further estimated the potential decrease in adverse health effects from improvements in indoor environments to be 10 percent to 30 percent for infectious lung disease, allergies and asthma; and 20 percent to 50 percent for Sick Building Syndrome symptoms (1). For the United States, the corresponding annual healthcare savings plus productivity gains are:

- $6 billion to $19 billion from reduced lung disease,
- $1 billion to $4 billion from reduced allergies and asthma,
- $10 billion to $20 billion from reduced Sick Building Syndrome symptoms,
- $12 billion to $125 billion from direct improvements in worker performance unrelated to health (1).

The indoor environment has become an important area of research in recent years. The past twenty years have brought the recognition that an important factor in the health of people in the indoor environment is the dampness of the buildings in which they live

and work (2-4). Furthermore, it is now recognized that the principal biological organisms responsible for the health problems in these environments are the fungi rather than bacteria and viruses (5). Fungi (mold) may play an important part in the symptoms associated with sick building syndrome (6). Gypsum building materials often become wet, resulting in mold growth that leads to health and productivity impacts, as well as liability and lawsuits. A major source for mold growth in schools, homes, and the work place is gypsum. It has been estimated that upwards of 40% of all homes in North America contain fungal growth on gypsum wallboard (7,8). The rapid growth and dispersion of mold can induce allergy and asthma episodes, while sometimes producing severe illnesses including pulmonary, immunologic, neurologic and oncogenic disorders (9-16).

Approximately 90% of the interior finished surfaces of buildings are covered with gypsum products. The United States produces an estimated 30 billion square feet of gypsum wallboard annually (17). Demand for gypsum products in the U.S., Canada and Mexico will grow by nearly 50% by 2007, reaching 46.8 million metric tons (18). Currently, 3 - 5 million tons, or 1% of the total North American waste stream, of gypsum board ends up as scrap material and is disposed of in landfills with much of this scrap the result of moisture and mold problems (19). Mold, being ubiquitous, can be found in any non-sterile environment, while upwards of 40% of all homes in North America contain fungal growth with gypsum wallboard being the primary growth material. Technologies that can reduce or prevent the growth of fungal organisms within the indoor environment could have a sizable positive impact on the health of building occupants.

Product Testing

Removal of growth substrates from building materials, or the incorporation of antimicrobial agents in the manufacturing of building products may prevent mold growth and the spread of biological contaminants. There are several gypsum products readily available that can reduce mold growth in the indoor environment. However, there is no nationally accepted testing and verification program to guide consumers and building professionals on how to select or specify the best gypsum products for their needs. This testing and verification will be carried out as a collaboration among numerous gypsum manufacturers and the EPA under ETV-ESTE. Multiple EPA offices (OAR, ORD, and OSWER) and private sector organizations (e.g., the U.S. Green Building Council, and the Gypsum Association) have shown interest in verifying the value of these advanced gypsum products. The evaluation of gypsum wallboard will test the following: (1) mold growth, (2) moisture absorption, and (3) volatile organic compound (VOC) emissions. Established methods will be used to form the basis of each of the evaluation criteria.

The goal of the project is the generation of a product evaluation system that will establish the performance of mold resistant building products. This evaluation system can then be used to test building products, the first of which is gypsum wallboard. This system is intended to be used by building professionals and the consumer public, enabling them to make informed decisions regarding the use of different building products.

The establishment of a microbial resistant gypsum wallboard (MRGW) evaluation system, along with a campaign of public education, will change the way that gypsum wallboard is manufactured and purchased. Consumers will be able to discriminate

between gypsum wallboard products and choose MRGW grade that best meets their needs. Manufacturers not producing MRGW may initiate production, and those already producing MRGW will strive to improve their products. The long term statistics for the probability of mold growth on gypsum wallboard can be drastically changed by MRGW. MRGW can reduce the likelihood of mold growth, the human exposure and detrimental health effects associated with mold growth, and generation of waste material to be disposed of in landfills.

References

1. Environmental Health, Safety and Quality Management Services for Business and Industry and Federal, State and Local Government. IAQ Fact Sheet.April 23, 2004. www.ehsservices.com/IAQ_stats.htm.

2. Vesper, S.J., Vesper, M.J., 2002. Stachylysin may be a cause of hemorrhaging in humans exposed to *Stachybotrys chartarum*. Infection and Immunity. 70(4):2065-2069.

3. Dearborn, D.G., Yike, I., Sorenson, W.G., Miller, M.J., Etzel, R.A., 1999. Overview of investigations into pulmonary hemorrhage among infants in Cleveland, Ohio. Environ. Health Perspect. 107:S495-S499.

4. Vesper, S.J., Dearborn, D.G., Yike, I., Allen, T., Sobolewski, J., Hinkley, S.F., Jarvis, B.B., Haugland, R.A., 2000. Evaluation of *Stachybotrys chartarum* in the house of an infant with pulmonary hemorrhage: Quantitative assessment before, during, and after remediation. J. Urb. Health. 77:68-85.

5. Scheel, C.M., 2001. Possible sources of sick building syndrome in a Tennessee middle school. Arch. Environ. Health. 56(5):413-418.

6. De-Wei, L., Yang, C.S., (2004) Fungal Contamination as a major contributor to sick building syndrome. In: *Sick Building Syndrome* (Straus, D.C., ed.). Elsevier Academic Press, San Diego, California, pp. 31-112.

7. Brunekreef, B., Dockery, D.W., Speizer, F.E., Ware, J.H., Spengler, J.D., Ferris, B.G., (1989) Home dampness and respiratory morbidity in children. *Am. Rev. Respir. Dis*. **140**:1363-7.

8. Nielsen, K.F., (2003) Mycotoxin production by indoor molds. *Fungal Genet Biol*. **39**:103-17.

9. Meklin, T., Haugland, R.A., Reponen, T., Varma, M., Lummus, Z., Bernstein, D., Wymer, L.J., Vesper, S.J., (2004) Quantitative PCR analysis of house dust can reveal abnormal mold conditions. *J. Environ. Monit*. **6**:615-620.

10. Vesper, S.J., Varma, M., Wymer, L.J., Dearborn, D.G., Sobolewski, J., Haugland, R.A., (2004) Quantitative polymerase chain reaction analysis of fungi in dust from homes of infants who developed idiopathic pulmonary hemorrhaging. *J. Occup. Environ. Med*. **46**(6):596-601.

11. Andersen, B., Nielsen, K.F., Jarvis, B.B., (2002) Characterization of Stachybotrys from water-damaged buildings based on morphology, growth, and metabolite production. *Mycologia*. **94**:392-403.

12. Etzel. R.A., (2003) *Stachybotrys*. *Curr Opin Pediatr*. **15**:103-6.

13. Vesper, S.J., Dearborn, D.G., Yike, I., Allen, T., Sobolewski, J., Hinkley, S.F., Jarvis, B.B., Haugland, R.A., (2000) Evaluation of *Stachybotrys chartarum* in the house of an infant with pulmonary hemorrhage: Quantitative assessment before, during, and after remediation. *J. Urb. Health*. **77**:68-85.

14. Kuhn, D.M., Ghannoum, M.A., (2003) Indoor Mold, Toxigenic Fungi, and *Stachybotrys chartarum*: Infectious Disease Perspective. *Clin. Microbiol. Rev*. **16**:144-172.

15. Dearborn, D.G., Yike, I., Sorenson, W.G., Miller, M.J., Etzel, R.A., (1999) Overview of investigations into pulmonary hemorrhage among infants in Cleveland, Ohio. *Environ. Health Perspect.* **107**:S495-S499.

16. Mahmoudi, M, Gershwin, M.E., (2000) Sick building syndrome. III. *Stachybotrys chartarum*. *J. Asthma*. **37**:191-198.

17. Wolkowski, R.P., (2003) Using recycled wallboard for crop production. University of Wisconsin Extension Document A3782.

18. Research Studies, (2003) Gypsum products demand in North America to reach 47 million metric tons. Freedonia Group, 767 Beta Drive, Cleveland, OH 44143-2326.

19. Musick, M., (March 1992) Recycling gypsum from C&D debris. *BioCycle*. pp. 34-36.