Assessment of Mold Resistance Performance for Building Materials in Humid Subtropical Zone

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Abstract

Taiwan is located in the humid subtropical climate zone and surrounded by the sea. The indoor environment of buildings is typically prone to being moist. It can also be easier for the fungus to grow in the condition of leakiness and stuffiness. If the fungus spores spread out in the air to fall on building materials and grow on their surfaces, the materials and furnishings would be damaged. Therefore, the purpose of this study is to strengthen the assessment of mold resistance performance of building materials and to preserve the human health in indoor environment. In this study, a series of experiments of fungi growth based on the ASTM Standard G21 of different building materials were performed. The results showed that the mold resistance characteristic of plywood and silicone is less than that of other inorganic building materials. Moreover, the indoor environment will lead to better health, if the mold-resistance performance can be further involved into the healthy green building material label evaluation.

Keywords

mold-resistance, healthy green building materials, ASTM Standard G21

1. INTRODUCTION

People spend usually well up to 90% of their time indoor, where a number of health risks can come from the indoor air. In Taiwan, the current distribution of new and old buildings is 3% and 97%, respectively. The organic chemicals are widely used in household products such as materials, furniture, furnishings, paints and varnishes. Due to the use of the artificial chemical building material, the potential health risk of indoor environment may thus emerge. However, the other healthy performance of building materials is also an important issue, especially the aptitude for growth of mold.

Taiwan is located in the humid subtropical climate zone and surrounded by the sea. The indoor environment of buildings is typically prone to being moist. It can also be easier for the fungus to grow in the condition of leakiness and stuffiness, accompanied with inappropriate use and poor maintenance of buildings. If the fungus spores spread out in the air to fall on building materials and grow on their surfaces, the materials and furnishings would be damaged. Building materials exposed to moist conditions and with poor maintenance can lead to mold growth. Common materials susceptible to mold growth include porous materials and those with cellulose substrates. Several epidemiologic studies have reported positive associations between dampness related fungal exposure and respiratory morbidity of the occupants. Chi (2003) also identified the microbial genera present on the building materials of subtropical climate. In addition, materials may be treated with anti-microbial agents as a preventive step in some cases. The ability of these materials to support or to resist mold growth is often not well documented. Therefore, the potential for mold growth on building and interior furnishing materials is an important issue for the design, specification, and construction industry.

In 2005, the Environmental Protection Administration of Taiwan launched ten indicators of indoor air quality (IAQ) recommendation standard include carbon dioxide, carbon monoxide, formaldehyde, total volatile organic compound (TVOC), airborne bacteria, Fungi, suspended particulates, suspended particulates, ozone, and temperature. The main sources of indoor air pollutants were focused on volatile organic compounds (VOCs) emissions from household materials and products. Therefore, the indicators of formaldehyde and TVOC of materials were particularly used to evaluate the IAQ. However, the mold-resistance of materials was excluded. The purpose of this study is aimed to strengthen the assessment of mold-resistance performance of building materials and to preserve the human health in indoor environment. Meanwhile, the IAQ management law is currently drafted as well.

2. MATERIALS AND METHODS

2.1 Green Building Material Evaluation and Labeling System

The Green Building Material (GBM) labeling system of Taiwan was officially launched in 2004 to systematically and effectively evaluate the performance of green building materials (ABRI, 2007). The system carries out quantitative assessments and laboratory tests based on a variety of measures in different stages of the life cycle of a building. Its criteria and standards are established accommodating with the subtropical climatic condition. In addition, the regulation of at least 30% mandatory green building material utilization has also been involved into Taiwan's Building Code and become effective since July 2009.

The GBM system covers four major aspects, including Health, Ecology, Recycling, and High-performance. To date, 245 Labels have been conferred covering 2000 green products. Among these products, the healthy material occupies 77%. The percentage distribution indicates the health issue has been highly emphasized and points out the development trend of the building material market in Taiwan. The Healthy Green Building Material (HGBM) label for improving the indoor environmental quality requires low VOCs emissions. The emission rate of formaldehyde and TVOC are used to evaluate the healthy green building materials.

2.2 Experiment Design

A testing protocol has been established to determine how susceptible or resistant a product may be to mold growth. Based on ASTM Standard G21 that is designed to provide a quantitative measurement of microbial resistance on building materials with reliability and reproducibility across a wide variety of building materials, this test is designed specifically to address IAQ issues. It involves the study of molds most likely to contaminate products and, consequently, to contribute to poor indoor air quality. Materials are inoculated with mold and placed in static environmental chambers with increased humidity conditions. Mold growth is measured over time, and the results will indicate if a product is likely to support mold growth under these pre-defined environmental conditions.

In this experiment, a set of six samples with healthy green building material label including paint, silicone, plywood, and calcium silicate board with measured amounts of spores of mold is shown in Table 1. The first sample of water-base paint is incubated under controlled conditions at 85% RH (relative humidity) and 29℃ for four weeks. The second sample of water-base paint is incubated under higher temperature at 35℃. The material of water-base paint with anti-microbial agents is selected as third sample. The materials of silicone rubber sealant, plywood, calcium silicate board are selected as fourth, five, sixth samples, respectively.

In the test, a mix of *aspergillus niger, penicillium pinophilum, chaetomium globosum, gliocladium virens,* and *aureobasidium* was adopted. The amount of mold recovered from the coupons is quantified at time 0 and at the end of four weeks of incubation to determine the material's degree of resistance to mold growth. Results are reported on a scale of 0 to 4, with 4 being least resistant (highly susceptible to mold growth) and 0 being most resistant to mold growth, based on a quantitative count of mold colonies. Following the incubation period, each sample was visually examined for traces of mold growth and rated based on the amount of growth observed. If no growth or mere traces of growth were observed, samples were then further examined under a microscope. A series of observations were intended to indicate the relative resistance of the samples to microbial growth under favorable conditions. The resistance to mold growth was rated according to the amount of mold observed according to Table 2.

Table 1 A set of experiments of fungi growth for building materials

Description	Temperature (℃)	Relative humidity (%)	Sample size （mm）
1.water-base Paint A	29	85	50*50
2.water-base Paint A under higher temperature	35	85	50*50
3.water-base Paint B with anti-microbial agents	29	85	50*50
4.silicone rubber sealant	29	85	50*50
5.plywood	29	85	50*50
6.calcium silicate board	29	85	50*50

Table 2 ASTM G21 mold resistance rating system

Observed Mold Growth	Applied Rating
None	Rating 0
Traces Less than 10%	Rating 1
Light growth 10-30%	Rating 2
Medium growth 30-60%	Rating 3
Heavy growth more than 60%	Rating 4

3. RESULTS AND DISCUSSION

In this study, four different materials of water-base paint, silicone rubber sealant, plywood, and calcium silicate board were selected for testing. In the first stage, the water-base paint was selected to compare the mold resistance characteristic at different temperature and with anti-microbial agents, respectively. Three samples were tested and the result is shown in Table 3. All showed no growth after 28 days incubation. The results indicated that the mold resistance characteristics of three conditions for water-base paint were of no difference. The test determines microbial resistance of new building materials as manufactured and not as installed, soiled, or weathered.

Second, four different materials were selected to compare the mold resistance characteristic under same condition. The result demonstrated that water-base paint and calcium silicate board are resistant and silicone rubber sealant and plywood are susceptible to mold growth. Microbial resistance of plywood and silicone are relatively low. In other words, the results showed that the mold resistance characteristic of plywood and silicone is less than that of other inorganic building materials.

Finally, the feasibility analysis is performed to judge that the GBM system would allow the mold-resistance performance to be incorporated into the healthy green building materials evaluation and the result is shown in Table 4. The study suggested that alternative B would be a more feasible case. Therefore, the mold resistance performance will to be a guarantee item in the healthy green building material evaluation.

Table 3 Rating of the aptitude of building products for fungal growth

Description	Rating			
	Day 7	Day 14	Day 21	Day 28
1.water-base Paint A	0	0	0	0
2.water-base Paint A under higher temperature	0	0	0	0
3.water-base Paint B with anti-microbial agents	0	0	0	0
4.silicone rubber sealant	2	2	2	3
5.plywood	4	4	4	4
6.calcium silicate board	0	0	0	0

Table 4 Feasibility analysis

Description	Business as usual	Alternative A	Alternative B
	Emission rate of formaldehyde and TVOC are used to evaluate the HGBM.	Mold resistance is to be a mandatory item and incorporated into HGBM evaluation.	Mold resistance is to be a guarantee item in HGBM evaluation.
Technical feasibility	Good	Feasibility	Feasibility
Economic feasibility	Good	common	Marketable
Management feasibility	Good	unfeasible	Feasibility

4. CONCLUSION

In conclusion, we have to pay attention to mold growth problem to ensure the occupant's health while using building materials as interior decoration materials under the conditions at high relative humidity and high temperature. On the other hand, the mold resistance performance can be a guarantee item in healthy green building material evaluation. Therefore, the indoor environment will lead to better health, if the mold resistance performance can be further involved into the healthy green building material label evaluation.

5. REFERENCES

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6. Presentation of Author

Dr. Shih-Chi Lo has worked in the architectural industry for more than ten years since he joined the environmental control department at the Architecture and Building Research Institute (ABRI) in 1995. He received his M.S. and Ph.D. degrees in environmental engineering from National Taiwan University. His recent research areas include indoor environmental quality, healthy buildings, and healthy materials.