PROTECTING MASONRY SURFACES FROM MOLD GROWTH WITH MINIMUM RISK ANTIMICROBIAL AGENTS

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Abstract: Sanitation efforts in public institutions quietly operate behind the scenes to ensure comfort and safety of the building occupants. Without extremely consistent, detail oriented service, the aesthetic appeal and sanitation of surfaces can quickly deteriorate to a level that puts the occupants of a building at risk. Public restrooms are one of the most mission-critical areas in a janitorial regimen due to the number of revolving occupants and the activities conducted therein. Though a significant amount of research has been dedicated to developing sanitary architectural design practices, many of these practices were not utilized in prior construction and are not being adopted in new construction. This creates a critical and immediate need for coatings and sealants that can aid janitorial efforts in keeping surfaces clean and hygienic. Researchers from West Texas A&M University (Canyon, Texas, USA), in collaboration with Buffalo Technology Group LLP (Canyon, Texas, USA) explored several mixtures of antimicrobial additives that could be incorporated into commercially available masonry sealants to provide tile grout and other masonry surfaces with protection from fungi and bacteria. These additive mixtures were subjected to standardized microbiologically testing procedures against mold (*Aspergillus niger*) by agar diffusion disk method. Results from microbiological testing indicate that the sealants enhanced with the antimicrobial additives could provide surfaces that are inhospitable to fungi growth and propagation. These results are significant because the additive material eliminates the primary sources of aesthetic and hygienic contamination on masonry surfaces in public areas and can be easily and safely applied to existing and new surfaces without the additional environmental concerns of common sterilizing cleaners.

Keywords: Mold Resistant Coatings, Public Sanitation, Building Products, Minimum Risk Pesticides

Introduction

Fungi grow well in warm, moist environments, and are perfectly suited to the ecosystem within a large number of households throughout the world. Mudarri and Fisk report that *47 percent of all homes in the United States have substantial mold* and dampness (2007), and these unwanted house guests are wreaking havoc on our health and economy. In the US alone there are an estimated *4.6 million cases of asthma attributed to household mold growth* (2007). The travesty of this preventable sickness is also causing significant economic damage. Americans are estimated to spend $22.4 billion on various illnesses attributed to household mold (Mudarri, 2016). Researchers have recognized the importance of creating surfaces that resist microbiological growth and propagation, including that of mold and mildew, through surface chemistry (Morones (1998), Zhao (1998), Faille (2002)) and surface roughness (Vasilev, 2009; Zhao, 1998; Faille, 2002) in a host of industries. One method of creating surfaces that are inhospitable to microbiological growth is by doping a coating matrix with antimicrobial compounds. The authors recently demonstrated the feasibility and benefits of enhancing coatings to resist microbiological growth by enhancing a coating matrix with antimicrobial additives in a variety of industries and coating systems (Hunt et. al, 2017, Hunt, et. al, 2017, Hunt, et. al., 2016, Chiu, et. al, 2016). This method of enhancing existing coatings to provide more robust protection against microbiological organisms is a growing trend to fulfill the call of industry for a solution to the problems associated with microbial growth.

At the same time that there is a growing need for surfaces that resist microbiological growth, there is also an increasing demand from consumers for antimicrobial solutions that are more environmentally friendly and less toxic (Laroche, 2007). This demand, along with the growing concern over pharmacologically resistant strains of harmful microorganisms "Super Bugs" has produced a resurgence in the utilization of naturally derived antimicrobial agents to protect surfaces from microorganisms. These materials, some of which are classified as Minimum Risk Pesticides by the United States Environmental Protection Agency (EPA), inherently resist the growth of mold, mildew, and bacteria on their surfaces. These materials can be optimized for use in various coating matrices to resist microbial growth without the use of environmentally ambiguous compounds and procedures. One type of coating matrix that that could reap substantial benefits by possessing an antimicrobial surface from environmentally friendly materials is masonry sealant. Figure 1 shows mold growth in a bathroom with exposed grout and standard masonry sealant.

Figure 1. Mold growth on grouted surface in tiled tub surround

Tiled surfaces are a popular finish style for commercial and residential buildings throughout the world. Within tiled surfaces, the surface area of grout can be up to 50% of the total covered area depending upon the size of tiles and the thickness of the grout lines. The morphology of grout surfaces inherently collects and holds moisture while simultaneously resisting scrubbing and disinfecting efforts. These characteristics provide an excellent platform for microbiological growth and propagation on grouted surfaces. Sealing the grout with a variety of commercially available grout sealants can decrease the hospitality of the surfaces to harboring microbiological organisms, but even when coated with a sealant, grout lines are routinely the most microbial dense areas of a tiled surface and are often the first to become impacted by staining due to mold and mildew. By doping commercially available grout sealants with combinations of antimicrobial agents it may be possible to decrease microbial growth on grouted surfaces without the use of harsh chemicals or excessive scrubbing.

Materials and Methods

Experiments were performed to evaluate the effectiveness of several additive mixtures against *Aspergillus Niger* by utilizing agar diffusion disk method. A list of 6 potential antimicrobial agents were selected from the United States Environmental Protection Agency list of Minimum Risk Pesticides. Figure 2 shows the experimental coating additive solutions as mixed prior to experimentation.

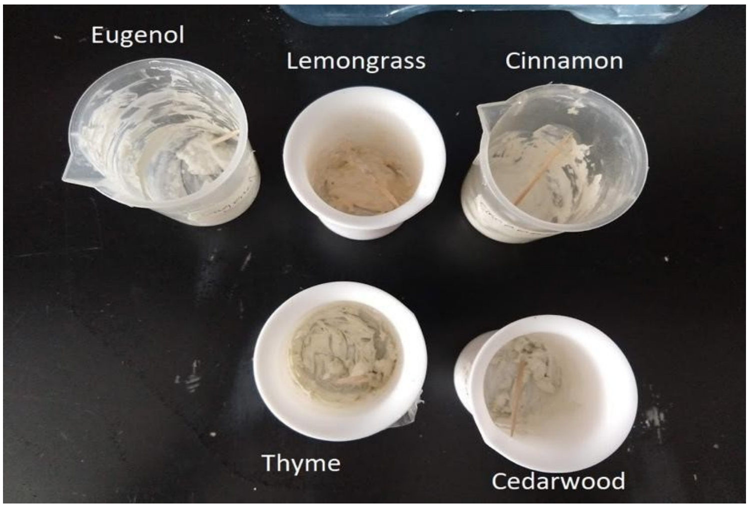

Figure 2. Mixtures of experimental antimicrobial agents

The independent agents shown in Table 1 were selected based on an extensive literature review and preliminary testing against various mold strains. The list features several essential oils as well as the active ingredient(Eugenol) in several more essential oils. Zinc Oxide, a known fungicidal compound, is also included in the list and has been used historically in cosmetics and sunscreens.

Table 1: Potential antimicrobial agents classified as minimum risk by the US Environmental Protection Agency.

Antimicrobial Agent	CAS Number
Thyme oil	8007-46-3
Cedarwood oil	8000-27-9
Cinnamon leaf oil	8007-80-5
Lemongrass oil	8007-02-01
Eugenol	8000-34-8
Zinc Oxide	1314-13-2
Thyme oil	8007-46-3
Cedarwood oil	8000-27-9

Using these chemicals, experimental sealant solutions, displayed in Table 2, were prepared using an industry leading, water-based commercial grout sealer. Lecithin was added to the experimental solutions to help suspend the active ingredient within the solution. Circular disks (6±0.5 mm diameter) of filter paper (Whatman Grade 1: 11 µm) were immersed in the various solutions and allowed to dry on waxed paper. Once dry, the samples were then placed on petri dishes filled with agar and inoculated with spores of Aspergillus Niger. The petri dishes were incubated at 25 C for 24 hours before examination.

Table 2: Experimental grout sealant solutions.

Sample	Components
A	Thyme India 20% in Coating w/ Lecithin & Water
B	Cedarwood Virginia 20% in Coating w/Lecithin & Water
C	Lemongrass 20% in Coating w/Lecithin & Water
D	Cinnamon Leaf 20% in Coating w/Lecithin & Water
E	Eugenol 20% in Coating w/Lecithin & Water
F	Control Coating
G	Composite Oil Mixture with Zinc Oxide
H	Control Coating

Results and Discussion

Qualitative analysis was performed on images of the petri dishes captured 24 hours after inoculation of the mold spores. The antimicrobial efficacy of each disk was categorized by the zone of inhibition created around the disk. Each disk was categorized as having no impact on the mold growth (0) whereby the boundaries of the disk were overcome by mold, having limited impact on mold growth (1) whereby the disks maintained their boundaries, or having significant impact on mold growth (2) whereby a zone of growth inhibition was created around the disks. These qualitative results are displayed in Table 3.

Table 3: Qualitative zone of inhibition results of experimental antimicrobial grout sealant mixtures against *Aspergillus Niger*.

Sample	Observation	Score
A	No impact	0
B	Limited impact	1
C	No impact	0
D	Limited impact	1
E	Limited impact	1
F	Limited impact	1
G	Significant impact	2
H	No impact	0

As described in Table 3 and shown in the photographs of Figure 3, samples B, D, E, and F showed slight inhibition of the mold. These samples maintained the boundary of the disks and were not overcome by mold growth. Furthermore, Sample G displayed significant impact to mold growth by creating a sizeable zone of inhibition around each of the sample disks. Samples A, C, and H had no impact on retarding the spread of mold onto the disks.

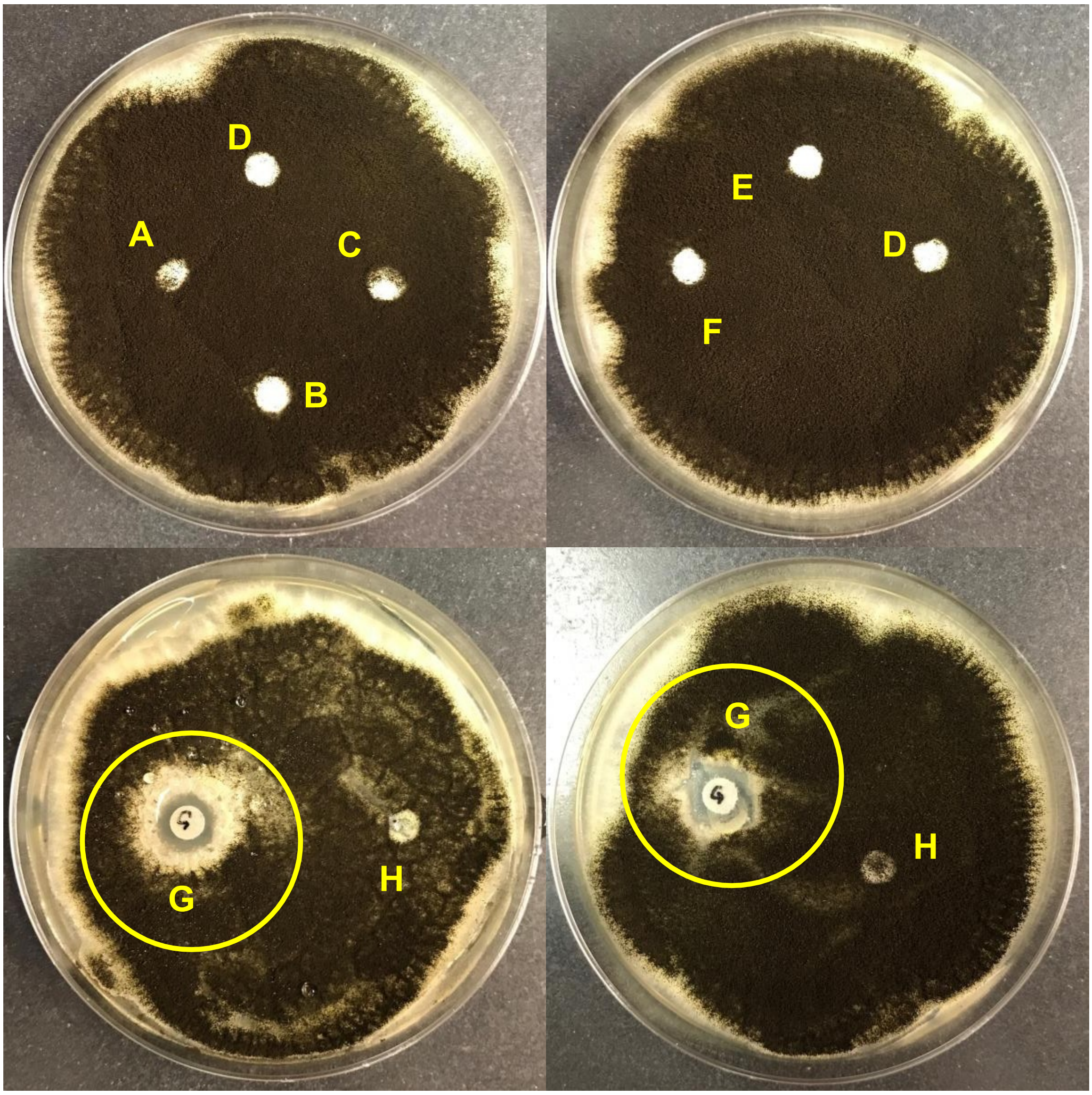

Figure 3. Zone of inhibition of experimental solutions 24 hours after mold inoculation.

Based on data from the images in Figure 3, G (composite oil mixture with zinc oxide) created the largest zone of inhibition and is the most effective solution for inhibiting mold growth. Sample H, which consisted of the leading commercial grout sealer on the market with no additional additive, did not inhibit mold growth in any way. In fact, it was overrun with mold growth. By using H as a baseline, it is apparent that every experimental solution from Table 2 improved the mold resistance of the coating.

Conclusion

The results of this study show that a composite solution of zinc oxide and various essential oils can be mixed within a commercial grout sealant to create an effective barrier against mold growth in laboratory settings. The solution created a significant zone of mold growth inhibition and could be a suitable solution for mold growth on masonry surfaces. This technology leverages the antimicrobial efficacy of materials classified as minimum risk by the US Environmental Protection Agency to create a solution to mold growth on masonry surfaces that is safe, effective, and exhibits limited environmental impact. Further investigation will be performed to determine the minimum concentration of antimicrobial agents necessary to inhibit mold growth on coated surfaces as well as explore any potential impact the additives have on clarity, surface morphology, and life expectancy of the coating,

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