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Effect of Fungal Growth on the Surface of Painted Plasterboards

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ABSTRACT

Paints contain many substances to improve their quality to protect the surfaces from environmental hazards. Mostly contamination of wall surfaces of the building by fungi. The fungi definitely grow when in high temperature and high relative humidity conditions and influence the capability of the building materials. The objectives this study to evaluate the efficiency of biocide based on bio-coating resistance test on painted plasterboards. The samples of fungal were collected by using an air sampler according to the National Institute of Occupational Safety and Health (NIOSH) by NIOSH Manual Analytical Method (NMAM 0800). Plasterboards were used as the substrate for two types of paints which are acrylic paint and glycerol-based paint was applied onto surface covering, then inoculated with 106 spores/mL of fungal suspension. Potassium sorbate was used as biocide treatment for the fungal growth. The Standard Test Method for fungi (ASTM D5590-00) used as a method to evaluate fungal growth and determine the biocidal activity of paints on plasterboard walls. The potassium sorbate was proved had the strongest effect on the growth of glycerol-based paint. Obviously, biocide used in paint is effective on most common fungi (mainly spores) in the air.

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INTRODUCTION

Nowadays the paints almost used to color and protect various surface from infection by fungi and termite as well as for decoration purposes. The application of paint on the construction materials does influence the several of a kind of fungal growth at the surfaces. Thus, among all the materials currently used in construction, in high relative humidity and temperature condition, it can be sensitive to the development especially for plasterboards. The most frequently detected fungal in plasterboard according to previous researcher are *Aspergillus Niger, Stachybotrys, Cladosporium* [1,2]. In addition, others fungal species found in contaminated dry paint film such as *Aureobasidium, Alternaria, Penicllium*. In addition, the fungal growth depending on climate, the substrate and the condition of the paint itself. Fungal organisms reproduce by producing spores, and these can be a significant health hazard to persons with respiratory allergies[3]. Previously, fungal growth will give some affect to the human health problems like itching, infection, allergies and toxic effects [4][5]. Most studies were carried in temperate region such as Japan's climate, with various months of high temperatures and relative humidity is fine suitable to the growth of several kinds of fungi[6] . Similarly, Shelton *et al*.,[7] found the fungal occurrence the indoor environment was during fall and summer seasons in United States. In addition, according to Frankel *et al.*,[8] high relative humidity and temperature are among the factors contributed to the higher occurrence of indoor fungi. Malaysia's weather is hot and humid with day and night temperature averaging 32^0C and 25 ^{0}C respectively is expected to have high microbial exposure [9,10]. In recent years, several studies have focused on antimicrobial coatings that can create healthy environment to prevent and protect the bio-deterioration of the substrates in buildings[11,12].This paper attempts to provide a more detailed investigation regarding the effects biocides in bio-coating resistance test against fungi by using paint and plasterboard

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substrates[12].

MATERIALS AND METHODS

Building materials:

The support is test such as plasterboards, were cut into samples of size 50mmx50mm. Two types of paint then used to cover samples with one layer of paint: acrylic paint and glycerol-based paint . The samples are carried out in triplicate at the same period.

Sampling location and technique:

The methods available for collecting fungal for this research are used biostage single-stage impactor viable cascade impactor attached to a SKC Quick Take 30 are. The malt extract agar (MEA) are using as the culture medium. In the air, impactors are used to collect the particles. Impactor is easier to handle and low cost to operate. Its consist multi-stage cascade, smaller holes at each stage and allowing particles to be separated according to size. The procedure for collecting fungal was followed the NIOSH Manual Analytical Method NAM 0800 [13].

Microorganisms:

Fungal cultures from the sampling were used in the coating bio-resistance tests, together with fungi isolated from several environments by culture on malt extract agar (MEA) media from contaminated indoor coatings. Species were cultivated in solid culture medium MEA (Merck KgaA) and distilled water for 25-30 days at 25^0C to favor fungal growth. Liquid media were used to prepare the fungal spore suspension. The complete liquid media contains NaCl 0.85%(w/v) and Tween 20 0.005%(w/v). Spores were transferred from the cultures and deposited in a flask with a solution. By using 'neubeuer chamber', the concentration was adjusted to 0.3-0.5x10^6spores/mL.

Coatings bio-resistance test:

In these study the substrate have been used such as plasterboard with two types of paint surface coverings, inoculated with spore of fungal. The plasterboards with paint were exposed to relative humidity to encourage fungal growth in incubator. The paints were applied on 50mmx50mm plasterboards previously cleaned with 70% alcohol and left to dry at 25^0C. Two coats of paints (acrylic paint and glycerol-based paint) were applied and left to dry for 24 to 48 hours before inoculation with the fungal spores. The painted plasterboards were irradiated with UV-lamp for 40 minutes, to avoid any contamination. Then the plasterboards were placed in a petri dish with MEA-agar. This medium was choosen for their poor growing conditions, to force the fungi to grow on the painted panel, as the carbon source. Four plasterboards were placed on each plate, one coated with the control paint and the other three with the paints containing the biocides. Fungi inoculums were prepared by growing each isolate in MEA for 25-30 days in the same condition than the other bioassay. A 50µl of the spore suspension was placed on the painted plasterboards, inoculated by a homogenous all over the surfaces, incubated at 25^0C and observed with regular observation 3, 6, 9, 12 and 15 days. According ASTMD5590-00 standard specification[14], the rate of fungal growth on paint films was assessed. Thus, observed growth on specimens equivalent to : none,trace growth (<10%), light growth (10-30%), moderate growth (30-60%), heavy growth (60-100%) has been rating as 0,1,2,3 and 4.

RESULTS AND DISCUSSION

Physical parameter:

During the sampling are being conducted, the fungal infestation on the wall and furnishing easily seen the visible microbial growth through visual inspection. Furthermore, in this room the odourless contaminations also present. Table 1 indicated the indoor air quality parameter measuring. All of this parameter significantly for this condition with high moisture content in the sampling site and may cause the microbial growth. From Table 1 show the high relative humidity is 90% was recorded at the site location, upper the recommended by DOSH (2010)[15] range from 40%-70 %.

Table 1: Measurement of the specific physical parameters according Industry Code of Practice on Indoor Air Quality 2010 (DOSH)

Parameter	Units	At Site location	Acceptable Range Indoor Air Quality Guidelines /Limits (DOSH)
INDOORS			
Relative humidity	%	90	40-70%
Air temperature	^{o}C	25	23-26^{o}C
Carbon dioxide	ppm	C743	C1000ppm
Air movement	m/s	0	0.15-0.50 m/s
OUTDOORS			

Relative humidity	%	78.2	*n/a
Air temperature	°C	28.9	*n/a
Carbon dioxide	ppm	C409	*n/a
Air movement	m/s	0.1	*n/a

**Notes: n/a: not applicable*

The coatings bio-resistant test:

The summaries from the evaluation of the coating samples exposed to fungal isolates on painted plasterboards using acrylic paint and glycerol-based paint during 15 days are shown in Table 2 and Figure 1. The capability of the biocide to prevent fungal growth in indoor buildings was indicated by the growth of fungi according to ASTM D5590-00 standard scale.

Table 2: Bio-coating resistance test with treated two types of paints. Lagend; none = trace of growth (<10%), light growth (10-30%), moderate growth (30-60%), heavy growth (60-100%)

Coating bio-resistance test	Day 3	Day 6	Day 9	Day 12	Day 15
	ASTM D55900				
Biocide-free acrylic paint + plasterboard	0	5	5	10	20
Biocide-treated acrylic paint + plasterboard	0	5	5	10	20
Biocide-free glycerol-based paint + plasterboard	5	5	10	10	20
Biocide-treated glycerol-based paint + plasterboard	0	0	0	5	5

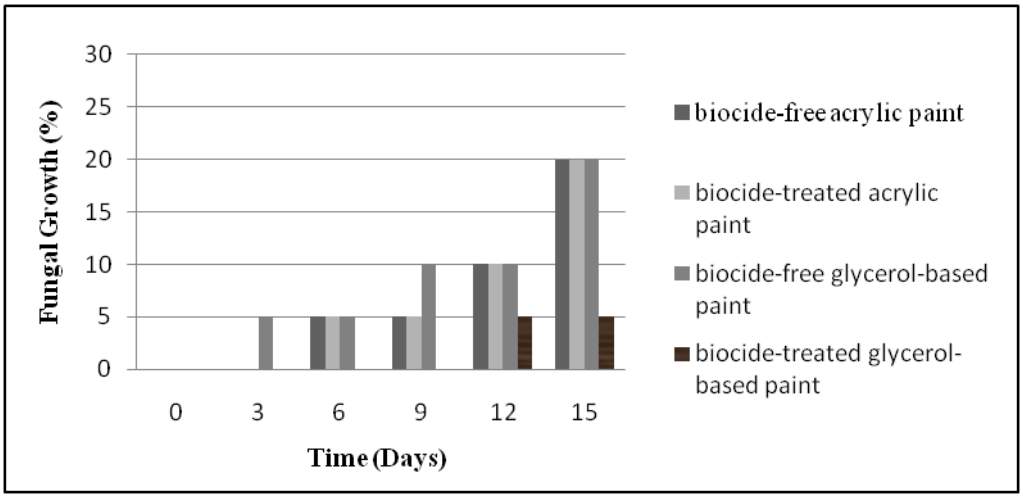

Fig. 1: Graph of fungal growth percentage versus incubation time for acrylic and glycerol-based paint.

Figure 1 shows the percentage of fungal growth according to ASTM standard rating for substrate with wall finishing of acrylic paint. The comparisons for the fungal growth were shown the application of biocide and without biocide at the wall finishing within 15 days. From the figure 1, the growth of fungal for control and biocide treated sample both started to occur on day 6th that is 5% and remain the same on day 9th. On day 12th, the growth for the control sample increased to 10%, and 20% for day 15th. While for sample with biocide, the growth only occurred on day 12th and 15th was the same, and the highest rating was only 5% for biocide treated sample. The substrates covered with acrylic paint were infested by fungi after 6 days of incubation. On that time, the mycelia growth with the plasterboards treatment. The growth of fungal on the paint mainly depends on the period and temperature. This problem will need the paint to be applying at low temperature and high humidity that contribute to fungal growth. However in some application, the paint can tolerate to moisture due to high polymer molecular weight [16]. For the wall finishing glycerol-based paint the comparisons for the fungal growth were shown the application of biocide and without biocide at the wall finishing within 15 days. From the graph, the growth of fungal for the control sample begin from day 3rd, 5% then increased on day 9th by 10% and increased to 20% of day 15th. While the fungal growth for the sample with biocide only had growth of 5% on day 12th. The highest rating for the control sample is 20% (light growth), and sample with biocide is 5% (trace of growth). Regarding substrates covered with glycerol-based paint, mycelia development from the beginning of incubation with very rapid surface (3 days). Even though glycerol can give flexibility and toughness in paints and coatings surfaces, but the characteristic of the glycerol itself will be able to retain moisture that lead to fungal growth[17].

The most critical factors for fungal development are the humidity or moisture content and temperature conditions at the material surface as well as the exposure time and the type of material. As state by Ritschkoff *et al*., [18,19] the fungal growth intensity and rate and even the possibility of initiation of growth depends on the

nutrition and pH-level of the material surface, and type. However, there are several aspects that have to be taken into account in the interpretation of the experiments and analysis of the fungal growth levels [19,20,21]. In real life, the humidity conditions will vary during the test. Finally, the results of this study should be considered as preliminary as only used a constant temperature are tested. In these conditions (25^0C and relative humidity), fungi growth is favored, correspond to buildings in humid climatic conditions and high temperature.

Conclusions:

The results and findings of this study can be concluded that the indoor environment in the building provides a nearly ideal environment for fungal growth; as temperature and relative humidity in the complaint area were both exceeded the acceptable range by ICOP. The finding of this study of the application of potassium sorbate was successful as the reduced growth in the treatment sample was observed. The measurement technique used in this study was able to provide a precise approximation for actual building practice in several parts. The outcomes of this study shall be considered as preliminary data for constant of temperature tested. For the future study, improvements are needed in the treatment to specific microbial agent and extend the observation period of fungal growth on the substrate for further measurement.

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