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Biodeterioration of fabric paints by fungal species and their control using antifungal agent

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Abstract

Paintings are essential components of culture heritage all over the world. Paints consist of organic and inorganic nutrients that can stimulate the growth of the microorganism. Many of the components present in paint are biodegradable. Paint is used for the protection of the substrate materials. The purpose of paint is to provide good appearance. Paint is a surface coating polymer based products. It is often discoloured by mould and blue stain, this leads to loss of paints. Biodeterioration arise from interaction among substrate, environment and organisms. The fungi degrade the paint film by producing extracellular enzymes such as ligninase, cellulose and organic acids. The most commonly used method is the addition of antifungal agent in the paint composition, which may acts as a biocide and inhibits the mould growth on paint and painted surface. Therefore the present study was aimed to isolate and identified the mouldy growth on fabric paints especially in green and red colors. The effective control of fungi in the paints was controlled using appropriate antifungal agent. Silver nitrate is very effective in killing fungal species that causes decay and deterioration of paint or paint film even at low concentration.

Keywords: Biodeterioration, Paint, extracellular enzymes, Silver nitrate.

Introduction

Paintings are essential components of culture heritage all over the world. Paints consist of organic and inorganic nutrients that can stimulate the growth of the microorganism. Many of the components present in paint are biodegradable. It consists of additives, glues, thickener, emulsifier and also some of organic molecules such as gums, sugars, oils, waxes, polysaccharides and proteins (Cifferi, 1999). That may utilize as nutrients by the organisms for their growth.

Biodeterioration arise from interaction among substrate, environment and organisms. A biological attack will occur when conditions such as temperature and relative humidity are favourable to the growth of organisms and spores are present on paint cause structural change. It leads to pigment discoloration, cracking, formations of paint blisters and detachment of paint layer. Many fungi and bacteria cause biodeterioration of which fungi are particularly dangerous. There require low relative humidity for their development and produce spores that can be easily dispersed in air. These conditioned are particularly favourable to fungal growth, the hypha growth on the paints causes exfoliation, side cracking, loss of paints and colored stains (Petrova *et al*., 2007). The principle factors affecting the growth of moulds on paint may be, nutrients, moisture, infection and formulation. The fungi degrade the paint film by producing extracellular enzymes such as ligninase, cellulose and organic acids that enable them to colonise any substrate that could supply free carbon as nutrient.

Biodeterioration can be controlled by physical methods includes treatment with gamma rays, UV and laser radiation. The mechanical methods include physical removal of bio deterioration by hand or with tool. The chemical methods includes use of chemical agent that act as antifungal agent like, Zno and Titanium dioxide. (Albinas luguskas and Bronious Jaskelevicious, 2007). The most commonly used method is the addition of antifungal agent in the paint composition, which may acts as a biocide and inhibits the mould growth on paint and painted surface.

Therefore the present study was aimed to isolate and identified the mouldy growth on fabric paints especially in green and red colors. The effective control of fungi in the paints was controlled using appropriate antifungal agent (silver nitrate).

Materials and Methods

Collection of paint samples

The contaminated fabric paints particularly green and red colours were collected from paint shop near at Polur, Thiruvannamalai District.

Isolation and Characterization of fungi

From the contaminated fabric paint, the fungal species were isolated by serial dilution methods using PDA media. The fungal morphology was identified by using lacto phenol cotton blue method. The identified fungal isolated were maintained in Potatoes Dextrose agar.

Determination of fungal growth on fresh fabric paints

Potatoes Dextrose agar was prepared with fresh different colors (Green and Red) of fabric paints and poured into petriplates. The fungal species were inoculated into the agar plates using a sterile teasing needle. The plates were incubated at 25-28^{0}C for 5-7 days. A control plate was maintained.

Determination of fungal growth on different concentration of fabric paints

The ability of fungal species to grow in high concentration of paint was determined by dilution method. The 100ml of Potatoes Dextrose broth was prepared with different concentration of paints like, 50 ppm (0.049g/lit), 150 ppm (0.149g/lit) and 250ppm (0.249g/lit) in 250ml sterile conical flask.

Determination of proteolytic activity from isolated fungi

The protease producing ability of the isolated fungal species was screened by proteolytic test. The protease indicator medium was prepared and poured into sterile petriplates. The fungal isolates were inoculated on the agar plates using sterile needle and incubated for 5-7 days and observe the zone of inhibition.

Antifungal activity test on paint

The effect of antifungal agents (silver nitrate) to controlling the mould deterioration on paint was determined by agar well diffusion assay. Potatoes dextrose agar medium was prepared and poured into sterile petri plates. Four wells were made by using well puncture at 5 mm in diameter. Different concentration of silver nitrate was prepared (like 50, 100 and 150 ppm) and 50µl was pipette out in each concentration and add into the wells and the plates were incubated at 25^{0}C-28^{0}C for 5-7 days.

Results and Discussion

Paint is used for the protection of the substrate materials. The purpose of paint is to provide good appearance. Paint is a surface coating polymer based products. It is often discoloured by mould and blue stain, this leads to loss of paints. Therefore the present study was reported that, the deterioration effect caused by fungi and their control activities.
Nichs, that provides sites for microbial attachment. The individual components of paint often provide biodegradable product can be attacked during production in pre-scale storage and as the reusable residues. Similarly in the present study observed that, three fungal isolates were obtained from contaminated fabric paints and identified as *Aspergillus niger*, *A. flavus* and *Rhizopus* sp based on their morphological view on both plate and microscopic observation. The fungal growth was observed in PDA supplemented with fresh fabric paints with different colors (red and green), from that media *A. niger* and *A. Flavus* were showed predominant growth on red color paint supplemented media, were as *Rhizopus* isolated from green color paint supplemented PDA plate.

In this study reported that, fungi when inoculated on different concentration of fresh fabric paints contained in sterile petridishes serving as medium, it showed some growth and estimated (in dry weight). The results showed, the red color paints enhance the growth of fungi when compared with green paints. The addition of 50 ppm fabric paints to PDA medium,

stimulated the growth of *A. flavus* (23 mg/ml), *A. niger* (15.5 mg/ml) and *Rhizopus* (23 mg/ml) in red color paint (Table,1). Similarly, increasing the concentration of fabric paints to 150 and 250 ppm it may reduced growth of fungi in both colors.

Table.1 Determination of fungal growth on different concentration of fabric paints

Organism	Dry weight mg/flask					
	Red			Green		
	50ppm	150ppm	250ppm	50ppm	150ppm	250ppm
A.flavus	15.5	20	25	12.3	16.2	23.4
A.niger	23	34.3	63	18.3	27.4	46
Rhizopus	23	29.2	43.4	17.1	26.2	38

The fungi produce specific enzyme such as cellulase, protease and some organic acids that cause pigmentation and physical damage and bioderioration. Fungi are dangerous species because they can tolerate adverse environmental conditions and require low pH, it leads to the main cause of contamination (Albinas luguskas and Bronious Jaskelevicious, 2007). Similarly in the present study reported the proteolytic activity of isolated fungi on fabric paints with proteolytic medium. The fungal species produced proteolytic enzyme and formed clear zone in and around the fungal colonies. Among the three species *A. flavus* showed highest zone of inhibition followed by *Rhizhopus* sp and *A. niger.*

The paint degrading was determined by paint hydrolysis tests by growing fungal species on medium supplement with paint. In the same way the qualitative hydrolysis test of paint was done by Petrova *et al*., (2007) to determine the ability of the fungus to degrade hydroxyl ethyl cellulose in paint. The antifungal activity was studied with the help of silver ions. Silver is a potentially toxic metal to most of the microorganisms, that interact with cellular nucleic acids and enzymes active sites or absorbs on the all wall (Heaton *et al*., 1991). Similarly in the present study reported that, the antifungal activity was determined with different concentration of silver nitrate (50, 100 & 150 ppm) by using agar well diffusion method. The highest concentration of silver nitrate was recorded highest inhibition activity (Table 2). *A. flavus* was most susceptible to Silver nitrate followed by *A. niger* and *Rhizopus.* This result agreed with Amany kansoh *et al*., (2007) to prevent mould growth on paints using silver nitrate which showed effective result when compared to normal biocide used.

Table.2 Antifungal activity test on paint:

Fungal species	Zone of inhibition at concentration of using silver nitrate		
	50ppm	100ppm	150ppm
A. niger	16	23	28
A. flavus	18	26	31
Rhizopus	12	18	22

Diameter of well 5mm

Therefore the present study revealed that, deterioration of paint and paint films are the common problem in recent years. It cause structural damage to paints and leads to disfiguration, most of the spoilage of fabric paints are caused by species of *Aspergillus.* Silver nitrate is very effective in killing fungal species that causes decay and deterioration of paint or paint film even at low concentration.

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