Microbial Deterioration of Paints

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Abstract

Biodeteriorated painted surfaces and In-can paints in Onitsha, Anambra State of Nigeria were analysed. The effects of Biocides on the biodeteriogens were also investigated. Psueudomonas, Bacillus, Arthrobacter, Enterobacter, Staphylococcus, Micrococcus and Microbacterium were the bacterial genera isolated while Fusarium, Aspergillus niger, Aspergillus fumigates, Aternaria, Cladosporium and Mucor species Micrococcus and Fusarium were the fungal isolates. The frequency of occurrence of bacterial and fungal species of normal and biodeteriorated surfaces were found to be 90% for Aspergillus niger, 80% for Bacillus sp., 60% for Cladosporium sp.,40% for sp., 50% for Pseudomonas sp., 30% Alternaria sp., 20% for Arthrobacter, Enterobacter and Aspergillus fumigatus species. Enterobacter, Micrococcus, Bacillus, Pseudomonas, Aternaria, Fusarium, Cladosporium species and Aspergillus niger were able to utilize either of the paint samples (gloss and Emulsion paint) in the microbial challenge test. From the mean susceptibility of biodeteriogens to biocides, bacterial deteriogens were more responsive to biocides than the fungal deteriogens.

Key words: Deterioration, painted surfaces, In-can paints, challenge test**.**

INTRODUCTION

Microorganisms have a simple approach to life; they use whatever is available as a food source, attach themselves to practically all surfaces, multiply and build biomass (Allsopp *et al*., 2003). The natural decay and recycling of materials by a wide range of life forms including microorganisms is termed biodegradation and is perceived as a beneficial process but, biodeterioration may be defined as the deterioration of materials of economic importance by microorganisms; it is perceived as a deleterious process (Allsopp *et al*., 2003). Microorganisms have the potential to grow in liquid paint before it is applied and also on paint films after application (EA-UK, 2002). Fungi and bacteria both require water and consequently, neither can grow in solvent based coatings. Water borne coatings however, are potentially prone to in-can attack by both bacteria and fungi (Ross, 1980). If these organisms develop, they can cause a number of problems including viscosity loss, maladour, discoloration, gassing, frothing, sedimentation and pH change. Fungi, algae and bacteria can all grow on applied paint films and solvent based and water based coatings are susceptible. The effect of each class of organisms depends on the environment. Films of oil and water based paints are colonized by microorganisms on the outside and inside of buildings. This aspect of biodeterioration can both be unsightly and hazardous to health (Gaylarde and Morton, 2001).

MATERIALS AND METHODS

Sample source and collection

Eight fluid paint samples of water and oil based paints were collected from four paint industries (two industries that produce paints with biocides and two industries that do not) with sterile bottles. Four fluid paint samples of oil and water based paints were also collected from paint dealers in markets and shops with sterile bottles. Thirty-two samples of paint scrapings were collected randomly from both normal and biodeteriorated painted surfaces at different locations within Onitsha North and South local Government Areas of Anambra State with sterile scrapel, blades and containers (Okpokwasili and Iteun, 1996).

Raw materials (calcium oxide and red pigment) used in paint production was also collected for analysis.Ten replicate samples of painted surfaces with obvious deterioration were also collected for studies on the frequency of occurrence of isolates.

Microbiological analysis

Scrapings of painted surfaces were crushed using clean mortar and pestle. Five grams of each crushed paint chips were aseptically weighed out and suspended in 45ml of 0.1% peptone water. From this, 1ml of the stock samples were obtained for serial dilution (ten fold serial dilution) (Ogbulie *et al.*, 1998). For the fresh paint samples, the paint cans were shaken and 1ml (from different paints to be analyzed) each added to 9ml 0.1% peptone water. Thereafter, ten fold serial dilutions were also carried out as indicated above. After serial dilutions, 0.1ml of appropriate dilutions was inoculated unto fresh media for the isolation of the microbial flora according to Ogbulie et al., 1998

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Microbial challenge test

All isolates were subjected to microbial challenge test using freshly opened emulsion and oil paints to monitor their rates of paint utilization. Different test tubes containing 5ml each of sterile mineral salt media (broth) were prepared and labeled appropriately. One millilitre of different sterilized paint samples were incorporated into the media to serve as the only source of carbon to the microorganisms. After which, loopful amounts of different isolates were inoculated into the different test tubes. The test tubes were shaken for 2 weeks using a test tube shaker to increase aeration and rapid growth of microorganisms which would signify utilization. The rates of paint utilization by the bacterial isolates were read with a spectrophotometer at 540nm wavelength while that of fungi were measured by obtaining their dry cell weight. Isolates with very high utilization capacity from the readings were considered as biodeteriogens because of their high ability to utilize paints as their sole source of carbon.

Identification of bacterial isolates

pH determination

The pH analysis was carried out using the method of Ogbulie et al., 1998.

Application of biocides to biodeteriogens

Three commonly used paint biocides were used to check for effects on biodeteriogens using the disc diffusion method by (Ogbulie and Obiajuru, 2003).

The bacterial isolates were examined for colonial morphology as well as biochemical characteristics and staining reactions (Holt *et al.,* 1994, Ogbulie *et al*., 1998).

Identification of fungal isolates

Fungal identification was based on microscopic or colonial morphological examination using the color atlas by Koneman *et al*., (1979) and microscopic examination after lactophenol stain (Ogbulie *et al*., 1998)

RESULTS

Following the result from Gram-staining reactions, bacterial and fungal Identification tests, *Enterobacter* sp., *Micrococccus* sp., *Bacillus* sp., *Arthrobacter* sp., *Pseudomonas* sp., *Staphylococcus* sp., *Microbacterium* sp., *Fusarium sp., Alternaria sp., Cladosporium*

sp., Mucor sp., *Aspergillus niger* and *Aspergillus fumigatus* were isolated from different samples analyzed. *Staphylococus* sp., and *Mucor* sp. were isolated from raw materials used in paint production while *Enterobacter* sp., *Cladosporium* sp., and *Aspergillus niger* were isolated from markets and shops.Table 1: Frequency of occurrence of bacterial isolates from normal and biodeteriorated painted surfaces

Microorganisms	NS	NTI	(%)

Bacillus sp.	10	8		80
Pseudomonas sp.	10	5		50
Micrococcus sp.	10	4		40
Arthrobacter sp.	10	2		20
Enterobacter sp.	10	2		20
Microbacterium s	10	3		30

Key: NS => Number sampled, NTI =>Number of total isolates, PER =>Percentage

Table 2: Frequency of occurrence of fungal isolates from normal and biodeteriorated painted surfaces

Microorganisms	**NS**	**NTI**	**(%)**
Fusarium sp.	10	4	40
Aspergillus niger	10	9	90
Cladosporium sp.	10	6	60
Alternaria sp.	10	3	30
Aspergillus fumigatus	10	2	20

Key: NS => Number sampled, NTI =>Number of total isolates, PER =>Percentage

Table 3: Microbial challenge test of bacterial isolates in Gloss and Emulsion paints

Microorganisms	**Gloss (OD 540nm)**	**Emulsion**
Control	0.00	0.00
+ *Enterobacter* sp.	1.484	0.375
+ *Micrococcus* sp.	1.232	1.002
+ *Bacillus* sp.	2.167	1.372
+ *Pseudomonas* sp.	0.963	0.765
Arthrobacter sp.	0.411	0.471
Staphylococcus sp.	0.346	0.279
Microbacterium sp.	0.215	0.133

Key: + => High utilization capacity, OD => Optical density

Utilization capacity of fungal isolates in gloss and emulsion paints

Most fungal isolates utilized the emulsion paints better than the gloss paint and *Aspergillus niger* rated the highest.

Table 4: Microbial challenge test of fungal isolates in Gloss and Emulsion paints

Microorganisms	**Gloss**	**Emulsion (Dry cell weight)**
Control	0.00	0.00
+ *Aspergillus niger*	1.34	1.62
+ *Alternaria* sp.	0.95	1.58
+ *Fusarium* sp.	0.83	1.26
+ *Cladosporium* sp	1.02	1.44
Mucor sp.	0.31	0.20
Aspergillus fumigatus	0.15	0.27

Key: + = Higher utilization capacity

Mean response of biodeteriogens to biocides

The total mean responses of biocides; Rocima, Procel and Acticide were 4.35, 4.05 and 4.80 respectively, which indicates that the biocide Acticide was the most effective.

pH result

The pH result of In-can paint samples ranged from 8-10 (Basic) while that of paint chip samples ranged from 3-6 (Acidic).

Table 6: Mean response/ susceptibilities of biodeteriogens to biocides

Microorganisms	Rocima	Procel	Acticide	Total mean response	Standard deviations
Enterobacter sp.	0.85	0.64	0.98	0.82	0.17
Pseudomonas sp.	0.70	0.86	0.96	0.83	0.13
Micrococcus sp.	1.30	0.70	0.84	0.95	0.32
Bacillus sp.	0.60	0.65	0.90	0.72	0.21
A .niger	0.20	0.20	0.40	0.27	0.12
Cladosporium sp.	0.40	0.20	0.20	0.27	0.12
Alternaria sp.	0.10	0.50	0.40	0.33	0.21
Fusarium sp.	0.20	0.30	0.20	0.23	0.06

DISCUSSION

Vast genera of bacteria and fungi are associated with the deterioration of paints and painted surfaces. This was reflected in this study by the isolation of seven genera of bacteria namely: *Enterobacter, Bacillus, Micrococcus,Staphylococcus,Microbacterium, Pseudomonas* and *Arthrobacter* species and six genera of fungi which include *Aspergillus fumigatus, Aspergillus niger, Cladosporium, Alternaria, Fusarium* and *Mucor species.*

The presence of microorganisms like *Mucor, Bacillus and Staphylococcus* species in In-can paint samples suggests the lack of incorporation of biocides during paint production. Bacterial isolates also were mostly present in In-can oil paints while fungi were mostly found in emulsion paints. This probably may be because some bacterial organisms like *Pseudomonas and Bacillus* have been found to be capable of oil or hydrocarbon degradation and utilization (Okpokwasili and James, 1995) and so thrives in environments or medium with such nutrients, and the dominance of fungi in emulsion paints may be accounted to be the minimal requirement of fungi for growth (EA-Uk,2002).

Microorganisms (*Bacillus, Aspergillus niger* etc.) isolated from some raw materials used in paint production revealed the contamination of paints prior to their application on wall substrates. This could lead to increase in the rate of deterioration of painted surfaces as the organisms are present in the containers.

There were discrepancies in the number of isolates from normal and biodeteriorated painted surfaces. The number of microorganisms from biodeteriorated painted surfaces was much higher than that of the normal, and this difference in the number of microorganisms pertains to the fact that the painted surfaces were undergoing deterioration. The high number of organisms associated with deteriorated surfaces might have resulted from the breakdown of biocides and other paint components such as resins, binders etc. (Cifferri, 1991) in the paint films by the primary colonizers thereby making subsequent colonization of the surface by other microbes not only easy but rapid (Ogbulie and Obiajuru, 2003).

The contributory factors to the colonization and proliferation of microorganisms on painted surfaces could be attributed to the harsh climatic conditions associated with the tropics (Bravery, 1988) which reduce the quality of paints' components, most importantly the biocides (if added), and the nature of the paint used and the position of the painted building. The presence of *Aspergillus niger, Cladosporium and Bacillus* species in the normal painted surfaces and their dominance in the frequency of occurrence of isolates may suggest that they could be the primary colonizers and initiators of the biodeterioraton process in the painted surfaces.

The ability and non-ability of some isolates to utilize fresh paint samples could suggest that some of these organisms do not only colonize painted surfaces but also utilize some of the components of paint

present on the surfaces thereby causing and increasing the rate of deterioration by their activities while some do not actually or significantly participate in the biodeterioration processes but act as mere contaminants and colonizers. Of significance also from painted surfaces was the isolation of *Cladosporium, Bacillus, Aspergillus* species etc. that have a wide range of distribution in nature (Hurst *et al*., 2001). These organisms might have gained their entrances onto painted surfaces through dust, dirt, soot and other environmental factors and contaminants accumulating on the painted surfaces, which may also represent another significant source of nutrients to the microorganisms (Nugari *et al*., 1993).

However, the bacteria isolated from this research work were similar to those of Ogbulie and Obiajuru (2003), Okpokwasili and Iteun, (1996) and Karpovich-Tate and Rebrikova (1990), with the exception of *Microbacterium* species. The fungal genera were similar with those isolated by Tiano and Gargani (1991) and Okpokwasili and Iteun (1996) with the exception of *Aspergillus fumigatus and Mucor* species. The consistent isolation of this group of microorganisms could be an indication that they are the characteristic biodeteriogens of paints and painted surfaces with the exception of few organisms that could act as contaminants (Agrawal *et al*., 1989, Altenburger *et al.*, 1996, Ogbulie and Obiajuru, 2003).

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