

Presence of Volatile Organic Compounds in Fine Coat Paint Used in House Decoration in Benue State Nigeria.

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Abstract

Chemical assessment of liquid state green colored samples of Emulsion Fine-Coat paint, Texture fine-coat Paint and Oil-fine coat paint collectively referred to as fine-coat Paint normally produced and used in Nigeria for house painting was carried out by first detecting alcohols. To 2cm³ of the paint sample in a test tube was added 2cm³ of ethanoic acid, and a few drops of conc. H₂SO₄. This was boiled with care for 2 minutes, an ester was formed with a characteristic pleasant fruity smell. This indicated the presence of an alcohol. To a further 2cm³ of sample in a test tube was added a small amount of sodium metal (with care). There was a vigorous effervescence with the evolution of an odourless colourless gas with no effect on litmus paper. This confirmed the presence of an alcohol. 2 drops of sample was added to 2ml of 95% ethanol and 3ml of 2,4-dinitrophenylhydrazine reagent. It was shaken vigorously, and allowed to stand for 15 minutes. Formation of a precipitate was a positive test for ketones. To 2cm³ of AgNO₃ solution, was added 1 drop of dilute NaOH, and 1 cm³ of a little amount of paint sample and warmed on a water bath. Silver mirror was formed on the wall of the test tube confirming the presence of an aldehyde. The quantity of these compounds was assessed by the use of a small hand held monitor the RI VOC Meter extremely sensitive and capable of detecting contamination at 0.1ppm levels. The maximum values of 0.65ppm Formaldehyde 0.60ppm Acetone and 0.75ppm alcohol were obtained. VOCs are dangerous to human health and can cause harm to the environment especially indoors. Considering the results obtained above and viewed against international standards they are not acutely toxic, but instead have compounding long-term health effects, because the concentrations are usually low and the symptoms slow to develop.

Keywords: Dangerous Paints Hazards Contaminants and Ventilation

1 Introduction

According to EPA's Office of Research and Development's Total Exposure Assessment Methodology (TEAM) Study, (1985) a dozen common organic pollutants are 2 to 5 times higher inside homes than outside, regardless of whether the homes were located in rural or highly industrial areas. TEAM studies indicated that while people are using products containing organic chemicals, they can expose themselves and others to very high pollutant levels, and elevated concentrations can persist in the air long after the activity is completed. That volatile organic compounds (VOCs) are emitted as gases from certain solids or liquids including: paints and lacquers, paint strippers, cleaning supplies, pesticides, building materials and furnishings, office equipment such as copiers and printers, correction fluids and carbonless copy paper, graphics and craft materials including glues and adhesives, permanent markers, and photographic solutions and the ability of organic chemicals to cause health effects varies greatly from those that are highly toxic, to those with no known health effect. The extent and nature of the health effect will depend on many factors including level of exposure and length of time exposed eye and respiratory tract irritation, headaches, dizziness, visual disorders, and memory impairment are among the immediate symptoms that some people have experienced soon after exposure to some organics. Many organic compounds are known to cause cancer in animals; some are suspected of causing, or are known to cause, cancer in humans

Volatile organic compounds (VOCs) are organic chemicals that have high vapour pressure at ordinary, room temperature conditions. The high vapour-pressure results from a low boiling point, which causes large numbers of molecules to evaporate or sublime from the liquid or solid form of the compound and enter the surrounding air. An example is formaldehyde with a boiling point of -19°C(-2°F), slowly existing paint and getting into the air. VOCs are numerous, varied and ubiquitous. They include both human made and naturally occurring chemical compounds. Some VOCs are dangerous to human health or causes harm to the environment. Anthropogenic VOCs are regulated by law, especially indoors, where concentrations are the highest. Harmful VOCs are typically not acutely toxic but instead have compounding long-term health effects.

A major source of man-made VOCs is coatings, especially paints and protective coatings. Solvents are required to spread and protective film. Globally 12 billion litres of paints are produced annually and their typical solvents are aliphatic hydrocarbons, ethyl acetate, glycol ethers, and acetone. Diets-Stoye- (2006).

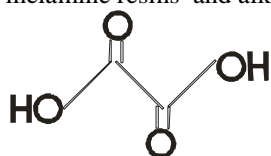
2 Paints

Dictionary.com (2011) defines paint as a liquid colouring matter used as a decorative or protective coating. Paint was used for pictorial and decorative purposes in the caves of France and Spain as early as 15,000 BC. The earliest pigments, which were natural ores such as iron oxide, were supplemented by 6000 BC in China by calcined (fired) mixtures of inorganic compounds and organic pigments; vehicles were prepared from gum arabic, egg white, gelatin, and beeswax. By 1500 BC the Egyptians were using dyes such as indigo and madder to make blue and red pigments. Encyclopædia Britannica, (2010) . Expressed here as Emulsion Fine-Coat paint ,Texture fine-coat Paint and Oil-fine coat paint it is typically made of three major components , pigment , gives paint its colour , binder , also known as the vehicle or medium, helps the pigment stick to the applied surface , solvent sometimes called carrier or thinner, keeps the paint in liquid form, making it easier to apply and diluents whose main purpose is to dissolve the polymer , adjust the viscosity and controls its flow but does not become part of the paint film. Water is the main diluent for water borne paints while organic solvents including aliphatics, aromatics, alcohols, ketones and white spirit act as diluents for oil borne paints. Specific examples are mineral turpentine commonly used as a paint thinner for oil based paints and cleaning of brushes .

These solvents contribute the most of the paints level of VOCs because the solvent is designed to evaporate quickly, leaving only the pigment and its binder (the solid) on the walls . Paint can have wide variety of miscellaneous additives, which are usually added in small amounts to modify surface tension, improve flow properties, finished appearance, wet edge, pigments stability, impact antifreeze properties, control foaming, and control skinning. These additives include catalysts, thickeners, stabilizers, emulsifiers, texturizers, adhesion promoters and UV stabilizers .

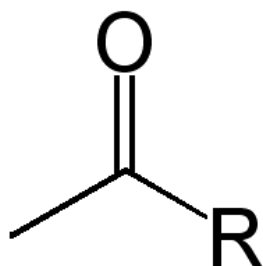
2.1 Chemical composition of paints

According to Wikipedia, the free encyclopedia the components of paint includes binder and resins , the binder, commonly called the vehicle, is the film forming component of paint and the only component of paint that must be present. Components listed below are included optionally, depending on the desired properties of the paint. The binder impacts adhesion and strongly influences such properties as gloss, durability, flexibility and toughness. Examples of binders include acrylics , vinyl-acrylics ,vinyl acetate ethylene VAE , polyurethanes , poly esters and melamine resins and alkyds - Oxalic acid-- ethanedioic acid

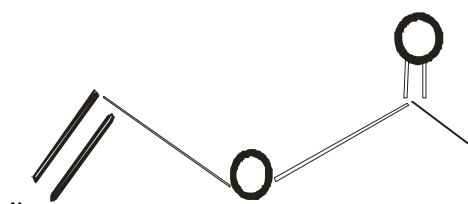


alkyds structure

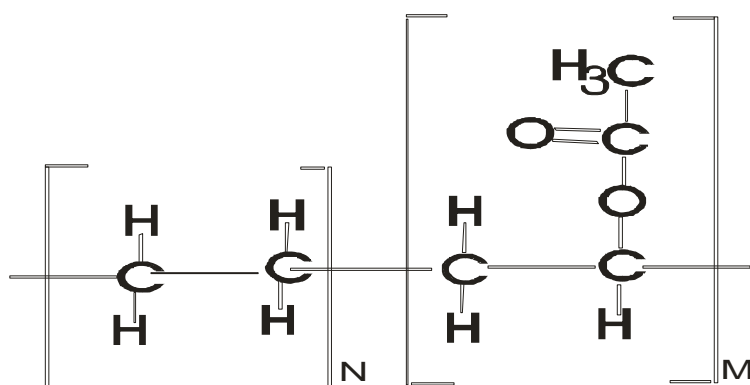
An alkyd is a polyester modified by the addition of fatty acids and are made with alkyd resin binder that has been modified with non yellowing drying oil for optimum color retention ,durability and drying time .Frank N J ones (2005)



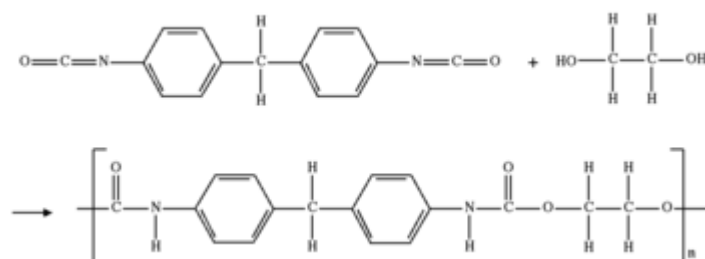
Structure of the acryl group
An acryl group [IUPAC alkanoyl] derived from a carboxylic acid



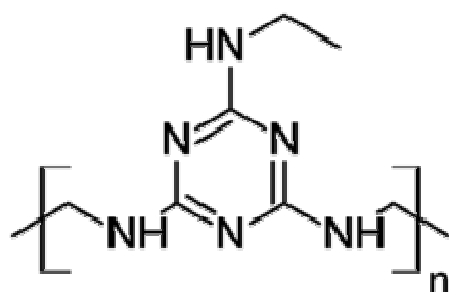
Structure of vinyl acetate which is primarily used as a monomer in the production of polyvinyl acetate and polyvinyl alcohol used as an emulsion in water as an adhesive.



Vinyl acetate/ethylene (VAE) a copolymer of ethylene and vinyl acetate . The weight percent vinyl acetate usually varies from 10% to 40% while the remainder is ethylene.



Polyurethane synthesis, wherein the urethane groups —NH-(C=O)-O- link the molecular unit. Polyurethane is used in manufacture of flexible, high resilience foam seating, in sulation panels,high performance adhesives. They are in a class called REACTION POLYMERS.



structure –n of melamine resin an organic base , and a trimmer of cyan amide also known as melamine formaldehyde is a hard thermosetting plastic material used in formica, melamine dinner ware and dry erase boards.

2.6 Applications of Paint

Primarily it ensures better adhesion to the surface, increases durability and protection for the material being painted. It can also be used to block and seal stains, for painting interior or exterior surfaces.

i. Paint can be applied as a solid, a gaseous suspension (aerosol) or a liquid. As a solid (usually used in industrial and automotive applications), the paint is applied as a very fine powder, and then baked at high temperature. This melts the powder and causes it to adhere. As a gas or as a gaseous suspension, the paint is suspended in solid or liquid form in a gas that is sprayed on an object. The paint sticks to the object. This is called “spray painting” an object. Thermochromic paints and coatings contain materials that change conformation when heat is applied and so they change colour. Liquid crystals have been used in such paints, such as in the thermometer strips and tapes used in aquaria. Photochromic paints and coatings contain dyes that change conformation when the film is exposed to UV light, and so they change colour. Colour changing paints can also be made by adding halochrome compounds or other organic pigments. Bramley, C (2004)

ii Primer is a preparatory coating put on materials before painting , it ensures better adhesion of paint to the surface, increases paint durability and provides additional protection for the material being painted. It can also be used to block and seal stains, or to hide a colour that is to be painted over.

iii Emulsion paint is water- based paint used for painting interior or exterior surfaces.

iii Finishing for paints is the ultimate , that is the aspect that makes the building look well constructed , eggshell finish has some sheen to it , provides great wash ability, is it ideal for bathrooms because it offers not only wash ability but has enough shine so water will not sick to it and make it peel . Pearl (satin) finish is very durable in terms of wash ability and resistance to moisture , it offers the user the full protection on their walls from dirt, moisture and stains also ideal for bathrooms, furniture, and kitchens . Semi-Gloss finish is typically used to add detail and elegance on wood work , high shine and most protection from moisture and stains on walls. This finish is generally used in schools and factories where wash ability and durability are the only consideration .

2.3 Potential dangers of components of paints

Volatile organic compounds (VOCs) in paint are considered harmful to the environment and especially for people who work with them on a regular basis. A. Spurgeon (2006) shows exposure to VOCs as been related to organic solvent syndrome, that high vapour pressure causes large numbers of molecules to evaporate or sublime from the liquid or solid form of the compound into the air, formaldehyde with a boiling point of $-19^{\circ}\text{C}(-2^{\circ}\text{F})$ is one example. As paint dries these harmful VOCs are released into the air at high levels. Indoor VOC levels are routinely 10 times higher than outdoor levels and up to 1000 times higher immediately after painting, they are the second largest source of VOCs emissions into the atmosphere after automobiles. Pennock G (2011). Painters regularly exposed to paint vapours have an increased incidence of several types of cancers, impaired brain function, renal dysfunction and other health problems according to International Programme on Chemical Safety IPCS (2011). kids tend to be more susceptible to the ill health effects associated with pollutants due to the fact that kids take in more air, relative to body size, than full-grown humans, and as a consequence their respiratory systems tend to be more vulnerable to certain chemicals, particles and allergens.

i. Alcohol is metabolized mainly in the liver in two stages and catalyzed by alcohol and aldehyde dehydrogenases, with NAD^+ as a hydrogen acceptor which oxidises 90% of the alcohol in the body, a chain of enzymes known as microsomal ethanol oxidizing system (MEOS) oxidizes not only alcohol but also several classes of drugs. The second enzyme that converts acetaldehyde to hydrogenase is present not only in the liver but also in the peripheral tissues. The excess alcohol is found in the blood, liver and in the brain causing drowsiness and impairment of these organs. The most commonly used alcohol is ethanol with the ethane backbone. Ethanol has been produced and consumed by humans in the form of fermented and distilled alcoholic beverages. It is used as an industrial solvent, car fuel, and raw material in the chemical industry. Methanol is extremely toxic: as little as 10ml can cause permanent blindness by destruction of the optic nerve and 30ml is potentially fatal, most significant possible effects of long-term exposure to alcohol in pregnant women causes fetal alcohol syndrome which is a pattern of mental and physical defect that can develop in a fetus during pregnancy. Nic, N eta (2006).

ii. Acetone is believed to exhibit only slight toxicity in normal use, and there is no strong evidence of chronic health effects if basic precaution are followed at very high vapour concentrations, acetone is irritating and like many other solvents, may depress the central nervous system. It is also a severe irritant on contact with eye, and a potential pulmonary aspiration risk. In one documented case, ingestion of a substantial amount of acetone led to systematic toxicity, although the patient eventually fully recovered. some sources ingestion at 1.159g/kg LD50 inhalation by mice is given as 44g/m^3 over 4 hours EPA EPCRA (1995). The metabolism of precursor of acetone, demonstrate that although exposure to high doses of acetone may cause transient central nervous system effects, acetone is not a neurotoxicant.

iii. Formaldehyde is a gas at a room temperature; it is colourless and has a characteristic pungent, irritating odour. It is an important precursor to many other chemical compound, especially for polymers. In 2005 annual work production of formaldehyde was estimated to 23 million tones (50 billion pounds) Gunther Reuss (2002). Commercial solution of formaldehyde in water, commonly called formaline were formally used as disinfectants and for preservation of biological

In view of its wide spread-use, toxicity and volatility, exposure to formaldehyde is a significant consideration for human health (Lyon 2006) On the 10th June 2011, the US National Toxicology Programme described formaldehyde as human carcinogen and is also widely used in industrial and medical settings and as a sterilizing agent, disinfectant, and preservative and employees may be highly exposed to it in these settings. Of particular concern are anatomists and medical students, who can be highly exposed to formaldehyde vapor during dissection sessions and susceptible children may be exposed to formaldehyde which is toxic over a range of doses; chances of exposure and subsequent harmful effects are increased as (room) temperature increases, because of its volatility.

3 . Methodology

3.1 Sampling

The samples were bought at paint dealers stores from two different areas in 4 litre buckets of packaged paints at Katsina-Ala and Gboko towns in Benue State. The samples were emulsion, texture and oil fine-coat paint.

3. 2 Materials and Methods

The samples were emulsion, texture and oil all of fine-coat paint. The material and reagents were Hot water bath , ethanoic acid concentrated sulphuric acid H_2SO_4 , sodium metal , 95% ethanol , 2,4-dinitrophenylhydrazine reagent silver nitrate solution $AgNO_3$, dilute sodium hydroxide $NaOH$,

3. 3 Detection

Here the fine coat paint samples were first used to detect the presence of alcohol , acetones and , Formaldehyde.

3.3.1 Test for alcohols

To $2cm^3$ of the paint sample in a test tube was added $2cm^3$ of ethanoic acid, and a few drops of conc. H_2SO_4 . This was boiled with care for 2 minutes , an ester was formed with a characteristic pleasant fruity smell. This indicated the presence of an alcohol.

To a further $2cm^3$ of sample in a test tube was added a small amount of sodium metal (with care). There was a vigorous effervescence with the evolution of an odourless colourless gas with no effect on litmus paper. This confirmed the presence of an alcohol.

3 .3.2 Test for ketones

2 drops of sample was added to 2ml of 95% ethanol and 3ml of 2,4-dinitrophenylhydrazine reagent. It was shaken vigorously, and allowed to stand for 15 minutes. Formation of a precipitate was a positive test for ketones.

3.3.3 Test for aldehydes (formaldehyde)

To $2cm^3$ of $AgNO_3$ solution, was added 1 drop of dilute $NaOH$, and $1cm^3$ of a little amount of paint sample and warmed on a water bath. Silver mirror was formed on the wall of the test tube confirming the presence of an aldehyde .

3.4 Analysis

VOC Monitoring

The RI VOC meter was used for detection of VOC at very low levels it is extremely sensitive and capable of detecting contamination at 0.1ppm level. The detection is performed by a technology called Photo-Ionization Detection (PID). The air is drawn into the detection chamber by a pump. UV light is used to ionize the molecule bonds in any chemicals that are present. These ions are electrically conductive and the meter detects the current that flows. The more contamination, the more conductive the air becomes. The device was started at the start button and used to sniff out areas of high VOC. An audible alarm sounded in areas where VOCs were higher than recommended and the concentration of VOCs present will be registered on the screen. RI VOC meter is calibrated in ppm. The unit was mounted on the wall and VOC levels read continuously for 8 hours as stipulated by U.S Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) per 8-hour time-weighted average (TWA) , as well as the American Conference of Governmental Industrial Hygienist (ACGIH) Threshold Limit Values (TLVs and STEL. All measurements were done on in-door painting. Samples of Emulsion Fine-Coat paint was labelled A ,Texture fine-coat Paint B and Oil-fine coat paint C and they were applied in the same order.

4.0 Results

FORMALDEHYDE

PAINT	15 MIN EXPOSURE PPM STEL	8 HOUR EXPOSURE PPM TLVs	8 HOUR EXPOSURE PPM TWA
A	0.65	0.45	0.40
B	0.55	0.40	0.40
C	0.60	0.50	0.65

KETONES

PAINT	15 MIN EXPOSURE PPM STEL	8 HOUR EXPOSURE PPM TLVs	8 HOUR EXPOSURE PPM TWA
A	0.60	0.40	0.30
B	0.50	0.35	0.30
C	0.45	0.40	0.40

ALCOHOL

PAINT	15 MIN EXPOSURE PPM STEL	8 HOUR EXPOSURE PPM TLVs	8 HOUR EXPOSURE PPM TWA
A	0.75	0.55	0.50
B	0.65	0.50	0.40
C	0.70	0.60	0.65

5.0 Observations and Discussions

The short-term exposure limit (STEL) values which measured the amount of the VOCs in 15 minutes was higher than those measured for 8 hours which indicates higher availability of the VOCs at the initial application. Nevertheless there was no dramatic changes even 8 hours later Time Weighted Average TWA, alcohol level of 0.75ppm was found in Emulsion Fine-Coat paint, 0.65ppm for Texture fine-coat Paint and 0.70 ppm for Oil-fine coat paint. The value of alcohol in Emulsion Fine-Coat paint -A was 0.75ppm at The short-term exposure limit (STEL) but dropped expectedly to 0.50ppm at 8-hour time-weighted average (TWA). Results for formaldehyde and ketones followed the same pattern but their intensity was lower than .

6.0 CONCLUSION

The presence of VOCs in fine coat paint was established in this work at various exposure levels. Despite the apparent low levels of VOCs in fine coat paint shown in the results, judging from the magnitude of their effect, cannot be overlooked. Relevant observations, rules and regulations needed to control exposure to and adverse effects be made public.

7.0 Recommendations

The best way to keep VOCs out of the air in our home is simply not to stay within its environment since it cannot be filtered out of the air the way dust and particulates can. Increased ventilation when using products that emit VOCs, opened containers of unused paints and similar materials, potentially hazardous products have warnings aimed at reducing exposure of the user, this is recommended. People sensitive to formaldehyde should try to avoid products that contain it. Formaldehyde is water soluble and reacts to temperature changes. This means that as the temperature and humidity go up so does the amount of formaldehyde released from a product. By keeping the temperature and humidity low, you can decrease the amount of formaldehyde off-gassing into the air.

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