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COMPARATIVE ODOUR ANALYSIS OF NATURAL RUBBER LATEX BASED PAINTS USING OLFACTOMETER

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ABSTRACT

Natural rubber latex based paints are water based which are devoid of solvents which emits harmful volatile organic compounds (VOCs) upon prolonged exposure. These types of water based paints are generally regarded to pose less detrimental effect to the health and environment due to minimal emission of VOCs during application. In the context of offensive smell, olfactory disturbances are rarely described in the use and application of latex based paints. Nonetheless, odour is still emitted due to the addition of various paint additives which are generally used to enhance the properties and working quality of paints, for instances viscosity enhancer, pigments, UV absorber and so forth. This paper describes the changes in odour concentration in an in-house developed latex based paint before and after incorporation of various paint additives. Using surface emission sampling technique via flux hood of stationary source of emission with subsequent dynamic olfactometry analysis, it is shown that the odour concentration increased with the presence of additives compared to pristine latex by at least 40%. The odour concentration of latex paints were much lower once applied onto substrates and further reduced by at least 33% after 14 days of application. Consequently the finding obtained from the olfactometry analysis is useful to give an additional perspective of characterisation for further development of minimum olfactory disturbance in natural rubber latex paint formulation.

Keywords: *Natural rubber; latex based paints; additive; odour emission; olfactometry.*

1. INTRODUCTION

Odour can be defined as the perception of smell resulting from the olfactory organ upon inhaling certain volatile matter. In order to assess or evaluate odour there are various available techniques of analysis such as electric nose, gas chromatography or olfactometry. In the analysis using olfactometer, a sample of odorous gas is diluted with neutral gas in defined ratio and presented to human assessors. Olfactometry is generally regarded as the most practical method among the others to assess odours concentrations because it uses the human nose as sensor. This technique has been widely used to assess odour impact from industrial and agricultural activities as described by Naddeo V. et al. (Naddeo, Zarr, Giuliani & Belgiorno, 2012) and Nor-Hidayaty K. et al. (Nor-Hidayaty, Nur-Fadhilah & Zairossani, 2012). Other techniques of odour measurements may offer better precision as an analytical technique but these methods may be inadequate to determine an individual's odour annoyance

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or the perception of offensive smell. However, the main disadvantage of olfactometry test is the variability of the test results and time necessary to perform the tests.

In the context latex based paint, a certain degree of unpleasant odours is associated to latex paints due to the volatile organic compounds (VOCs) in the paint. Using olfactometer techniques, a study was conducted to compare the odour concentrations in paints manufacturing factories. It is shown that the factory employing water based process exhibited a much lower odour concentration in the range of 910 to 1,700 ou/m^3 compared to another factory employing solvent based process with odour concentrations in the range of 1,400 to 11,000 ou/m^3 (Güvener, 2004).

Latex based paints when applied onto substrates emits odour. The odour of these paints over an extended period after the application is attributed to the decomposition of binder to form chemical by-products in the form of short chain aldehydes, ketones and fatty acid (Uchiyama, Jensen, Duval, Cetti, Woo & Archambault, 2002). These odours may also be emanating from paint additives or components for instances buffers, thickening agents, biocides or crosslinking agent (Hanzlicek, Fox, Dukles, Martuch, Andrews & Bedford, 2007). It is generally accepted that latex based paint is less hazardous than solvent based paints, the long term occupational exposure to the VOCs of latex paints are still inevitable. Although olfactory disturbances are less common in latex based paints in comparison to solvent based paints, eye and skin irritation are prevalent in exposed workers (Wieslander, Norbäck & Edling, 1994).

In the present study, the odour concentration of an in-house developed natural rubber (NR) latex based paint using an adopted surface emission sampling technique via flux hood of stationary source emission which normally conducted to collect surface emission odour like landfill and waste treatment pond. Subsequent analysis was later carried out by dynamic olfactometry technique. The analysis before and after incorporation of various paint additives was investigated with subsequent analysis on the odour emission during the drying of the paints after the application onto concrete substrates. The findings obtained from the olfactometry analysis are useful to give an additional perspective of characterisation for further development of natural rubber latex paint formulation with less odour emission thus provides better indoor air quality upon application of the paint.

2. EXPERIMENTAL

2.1. Preparation of NR Latex Based Paint

The NR latex used in the present study is epoxidised natural rubber (ENR) under trade name Ekoprena. It was obtained in latex form which is before the latex is further processed into dry rubber bale. The ENR latex has 25% epoxidation level and designated as ENR 25 with the value of total solids content at 30%. One litre of rubber latex paint was prepared using in-house proprietary formulation as shown in Table 1. Except for the pigment used, all other ingredients are bio-based and renewable materials.

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Table 1: Ingredients to prepare NR latex paint

Ingredients/Composition	Part per hundred rubber (phr)
ENR 25 latex (30% TSC)	100
Viscosity modifier	10
UV absorber	10
Pigment	1

2.2. Odour Sampling – Flux Hood Technique

Flux hood sampling is a technique for sampling and analysis of stationary source emission for the determination of contaminant emission rates from an area source, in particular the determination of odour and hazardous air pollutants. A flux hood is an enclosure device comprising an open cylindrical base, a sweep air supply line and perforated sweep air distribution system through the chamber's inlet (Australian/New Zealand Standard, 2009).

The use of flux hood chamber for odour sampling from the rubber latex paint samples or substrates after the application of paint is illustrated in Figure 1. The odour samples were collected from the chamber's outlet into nalophan bag using a built-in vacuum system in a sampling drum. Both analysis and sampling methodology can be referred to 'MS 1963: Air Quality - Determination of odour concentration by dynamic olfactometry' (Malaysian Standard, 2007) which corresponds to similar European Standard, EN 13725:2003.

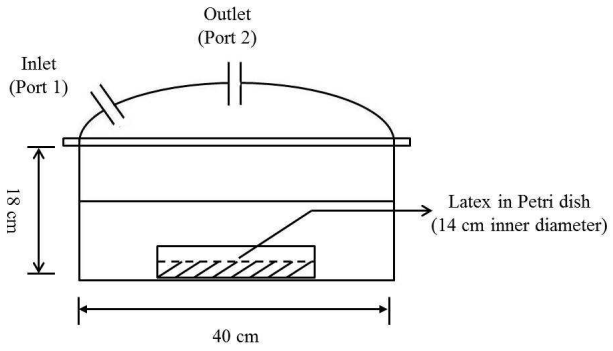

Figure 1: Odour sampling of NR latex paint using flux hood

The odour sampling parameter is shown in the flowchart (Figure 2) where it is presumed that the odour emanating from NR latex paint placed in a petri dish and latex paint after being applied on substrate with similar dimension would give similar rate of odour emission and the differences of odour concentration reflects the changes in the volatile organic compounds (VOCs) in the latex paint.

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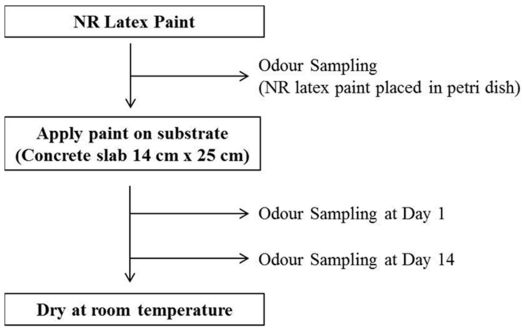

Figure 2: Flowchart indicating points of odour sampling

2.3. Olfactometer Analysis

The odour concentration in this study measured by olfactometry method where the concentration of a gaseous sample of odorants is determined by presenting a panel of selected and screened human subjects with the samples, varying concentration by dilution with neutral gas in order to determine the dilution factor at 50 % detection threshold. At that dilution factor, the odour concentration is 1 ou/m^3 by definition. The result of the analysis is subsequently expressed as a multiple (equal to the dilution factor at 50 % detection threshold) of one Malaysian odour unit per cubic meter (ou/m^3) at standard conditions for olfactometry. The accuracy and instability of instrument are smaller than 20 % and 5 %, respectively (Malaysian Standard, 2007). This inferred that the instrument is working at the optimum level of performance conforming to the MS 1963:2007 standard. The analyses were carried out using DynaScent Digital Dynamic Olfactometer manufactured in Australia, in a confined odour control laboratory where 60 ppm n-butanol was used as a calibration standard and control sample.

3. RESULTS AND DISCUSSION

The result of latex paint odour in its original form before being applied to substrate is shown in Table 2. It is shown that in its pristine condition devoid of additives to make paint, ENR 25 latex exhibited the lowest odour concentration value relative to the rest of the samples tested. Subsequent incorporation of additives such as UV absorber and viscosity enhancer increased the odour concentration by more than two-fold. Thus, it can be suggested that the sources of odour are more likely to be influenced by the additives in the latex paints rather than the latex itself. In comparison to commercial paints, the paint developed from ENR 25 latex indicated less odour emission with lower odour concentration values.

In order to illustrate better the effect of additives in the rubber latex paints further, odour was sampled at day 1 and day 14 after the paints are applied on concrete substrates. The reason why Day 1 or 24 hours were taken for sampling is due to common paint drying phenomenon where evaporation of the solvent present in the paint occurs during application and immediately thereafter. These odours are more intense during application of the paint and subsequently decrease until total evaporation. The time for complete evaporation is dependent

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upon the amount of solvent used and its evaporation rate. The duration period of where intense odour is detected is approximately 24-48 hours (Shuger, 1937).

Table 2: Results of odour concentration in NR latex paints and commercial paints

Samples	**Odour concentration (ou/m^3)**
Natural rubber latex (ENR 25)	1,821
ENR 25 latex paint (addition of UV absorber)	2,557
ENR 25 latex paint (addition of UV and viscosity enhancer)	5,965
Commercial latex paint 1	8,107
Commercial latex paint 2	9,180

Table 3 shows the results of odour concentration in NR latex paint at Day 1 and Day 14 after being applied on concrete substrates. The results indicated that the odour concentration in all the paints samples persisted after 14 days. ENR 25 latex paints showed the lowest level of odour concentration and highest reduction in odour was observed after Day 14 compared to the commercial latex paints. Between the two ENR 25 latex paints, the samples devoid of viscosity enhancer indicated higher odour reduction while for the commercial paints, the latex paint 2 sample exhibited better odour reduction at day 14.

Table 3: Results of odour concentration after being applied on substrates

Samples	**Odour concentration (ou/m^3)**		**Odour reduction (%)**
	Day 1	Day 14	
ENR 25 latex paint (addition of UV absorber)	877	439	50
ENR 25 latex paint (addition of UV and viscosity enhancer)	737	493	33
Commercial latex paint 1	1,752	1,486	15
Commercial latex paint 2	1,486	779	47

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Between the two commercial latex paints samples, latex paint 2 showed higher values of odour concentration. The odour level was shown to be markedly decreased after Day 1 of application and reduced further by 47% at Day 14. The results could not be clearly associated to type of additives which influenced the rate of evaporation hence the reduced perception of odour level, particularly for commercial latex paints.

This is owing to the nature of commercial latex paints which are more complex dispersion of polymer colloids in water together with numerous additives such as chemicals or particles to modify the colour or hardness of the coating, dispersant, de-foamer, rheology modifiers and so forth. When such dispersion is applied to a substrate and dried, the particles in latex deformed during the drying process attaining a homogeneous and non-porous coating (Christine & Lorraine, 2013). The difference in the substrates may also have a marked effect on the adsorption and desorption of chemicals used in latex paints. It is reported that concrete substrates have strong adsorption of VOCs and some compounds such as 2-(2 butoxyethoxy)ethanol, diethylphthalate and a latex stabiliser by the trade name Texanol, were either irreversibly adsorbed by the concrete or desorbed very slowly at undetectable levels (Silva, Vasconcelos, Santos & Fernandes, 2003).

In general, the comparative analysis in the present investigation indicated that the certain additives used in NR latex paints such as viscosity enhancer influenced the odour level of the latex paints. However, the high odour level of the latex paints themselves may not reflect that the odour level remained high after the paints are applied onto substrates.

4. CONCLUSIONS

Flux hood chamber sampling technique and dynamic olfactometry analysis method were conducted to compare the odour concentration in NR latex paints and commercial latex based paints. The results can be deduced as the following:

1. ENR 25 latex in its pristine state devoid of additives to make paint exhibited the lowest odour concentration as compared to the rest of the rubber latex based paints samples.
2. Incorporation of additives in ENR 25 latex paint particularly the viscosity enhancer has increased the odour concentration.
3. After the application of latex paints on concrete substrates, the odour had shown a reduction after Day 14 in different rates in all the paint samples tested whereby in general ENR 25 latex paints showed considerably lower level of odour concentration compared to commercial latex paints and ENR 25 latex paint with additional UV absorber demonstrated lowest reduction in odour as observed after Day 14.

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