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PRODUCTION OF EMULSION PAINT USING EXPANDED POLYSTYRENE AS A BINDER AND SNAIL SHELL AS FILLER

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ABSTRACT

Waste expanded polystyrene was dissolved in toluene and used as a binder for an emulsion paint formulation and also snail shell was ground to powder and used as a filler for replacement of PVA and $CaCO_3$ respectively, in five different proportions, the filler loading A, B, C, D and E. The iso – 12944 standard emulsion paint formulation and method of production was employed. All the five samples gave good quality emulsion paint in terms of density, drying time and pH except for samples A and B with pH 8 which is within the range where bacteria strive. Samples A, B, D and E had better rub fastness. However, the situation was observed that the paint viscosity decreased with increase in EPS. The higher the EPS and water content, the lower the viscosity of the paint produced. This study has found EPS solution as a potential binder and snail shell as filler in the coating industry.

KEYWORDS
Snail shell, expanded polystyrene, binder, emulsion paint, filler

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INTRODUCTION

Paint is regarded as one of the oldest synthetic substances known and having a history dating back to pre-historic times (Waldie & John, 1983). Paint is used to decorate, protect and prolong the life of substrates. It also acts as a barrier against environmental conditions (Turner, 2009). Pigment,

binder, solvent, and additives form the major paint formulation components (Jelena, 2012). The two terms “paint” and “surface coating” are repeatedly used interchangeably. Surface coating is generally used to describe any material that may be applied as a thin continuous layer to a solid surface. Paint on the other hand was conventionally used to describe pigment materials as distinct from clear films which are more properly called lacquers or vanishes. Paint is a loosely word enveloping a whole variety of materials; enamels, lacquers, vanishes, undercoats surface, primes, sealers, fillers, stoppers and many others.

Paint and coatings are generally classified into the following main categories; architectural coatings, product coating for original equipment manufacturers and special purpose coatings (Dean, 1981). Of these three main categories, emulsion house paints fall in the first category. Emulsion house paint is water based primarily used for internal and external surface coatings, predominantly in buildings for appearance as well as protection. The processes involved in the production, quality and performance of emulsion paint largely hinge on the properties of its constituents and the ratio of these constitutions (Akinterinwa *et al.*, 2015) The constituents generally used for the production of emulsion house paints include, prime pigments, solvent extenders, pigments binder and additives (Abdulsalam & Yahaya, 2010). While binder serves as the film forming agent that identifies the paint, additives improve the properties of paint (Khanna, 2008).

Binders (mostly PVA) usually take between 17-33% of the total cost of the constituents for the production of emulsion house paints depending on the paint type. This raw material is not available locally but imported hence, high cost of this raw material (binder) and consequently high cost of production due to the use of expensive binder. In addition, PVA is not environmentally friendly because of its non-biodegradability which can contaminate the environment if not properly

handled (Surajudeen & Zebulu, 2015). This is because PVA releases toxic fumes when burnt. It can be hazardous to the environment, especially if it is mixed with water and comes in contact with fish (Sun *et al.*, 2017).

Polymer material finds important application in paints and coatings industry. They are used for corrosion control, providing chemical and heat resistance to the coated substance as well as decoration. Special coating can provide common flag in military application, anti-fouling and anti-bacterial protection, and for many other reasons. The terms paints and coating sometimes are used interchangeably, but they differ in their meanings. Coatings are generally referred to materials utilized for protective and functional purpose. On the other hand, paints refer to materials used for decorative Purposes. However, there are similarities in terms of handling and to some extent composition. The four main components of a coating are;

Expanded polystyrene, also referred to as light weight cellular plastic material is produced from polystyrene. This material is modified by adding flame retardant additives. Polystyrene literally is "Polymerized styrene"; meaning that single styrene molecules are chemically linked together to form a giant molecule called the polymer. Styrene is produced from benzene and ethylene, and polymerization is accomplished in the presence of catalysts, usually organize peroxides. The expandable form of the polystyrene is produced as a small bead containing a blowing agent.

The snail shell is the hard part of the body of a gastropod or snail, a kind of mollusc. The shell is an exoskeleton, which serves as a protection from predators, mechanical damage or load, and dehydration, but also serves for muscle attachment and for storage of calcium. Some snails may also possess an operculum that seals the opening of the shell, known as the aperture, which provides further protection (Adewuyi & Adegoke, 2008).

Expanded polystyrene is produce in abundance in the country for food and electronics packaging, but a large quantity of the used ones is disposed to the environment constituting a great environmental pollution due to their because nonbiodegradability. Burning or burying of this material, will result to other forms of pollutions. Snail shells also constitutes environmental pollutions. Hence an attempt is made in addressing the problems caused by these two waste materials in this study by providing a useful material (paint) from the combination. This research is targeted at producing emulsion paint using waste expanded Polystyrene as a binder replacing Polyvinyl Acetate and also snail shell as a filler replacing calcium carbonate ($CaCO_3$).

Viscosity is a major physico-chemical property of car paint that determines its quality as it enhances the ease of apllication (good flow out of application mark such as paint sprayer) (Turner, 2000; Khanna, 2008; Alireza *et al*., 2009).

MATERIALS AND METHODS

Materials

Materials utilized in this research include the following: Distilled water, Calcium, Yellow ion dioxide (colorant), Snail shell powder filler, Titanium (surface cover), Waste expanded polystyrene (binder), Formalin and ammonia (anti-oxidant), Deformer (anti foam), Acrytex (mono ethylene glycol), Nitrosol (thickener) and Toluene (solvent).

Equipment

Table 1: List of equipment used for this research

S/No.	Operation	Equipment	Manufacturer's	Model No
1	Weighing operation	Weighing balance machine	Mantle instrument Cpy. Ltd.	AEk200
2	pH testing	pH meter	Mantle instrument	18-195.04
3	Drying	Vacuum oven	Cole parmer vacuum oven	6064.8
4	Viscosity testing	Viscometer	ICI rotorthiner	D120070
5	Abrasion resistance	Rub fastness	Fortuna-wepke machine	158/2FBm
6	Milling operation	Milling machine	Thomas-Wiley	4
7	Sieving operation	Sieves	ASTM Standard sieve	460

Formulation table

Table 2: The formulation table indicating the proportions of the materials for the emulsion paint

Material	A(g)	B(g)	C(g)	D(g)	E(g)
Distilled water	100	110	120	130	140
Calcium	5.0	5.0	5.0	5.0	5.0
Yellow ion dioxide	19.0	19.0	19.0	19.0	19.0
Snail shell powder	23.0	23.0	23.0	23.0	23.0
Titanium	15.0	15.0	15.0	15.0	15.0
EPS	5.0	7.5	10.0	12.5	15.0
Formalin	0.7	0.7	0.7	0.7	0.7
Ammonia	0.7	0.7	0.7	0.7	0.7
Deformer	5.0	5.0	5.0	5.0	5.0
Acrytext	2.0	2.0	2.0	2.0	2.0
Nitrosol	3.5	3.5	3.5	3.5	3.5

Sample preparation

Waste expanded polystyrene (EPS) was sourced in the surrounding and snail shell was sourced from Garki, Abuja. The waste EPS was dissolved in 250 g of toluene to get an EPS solution, while

the snail shell was crushed using mortar and pestle then further underwent ball milling for 24 hours to obtain fine powder which was sieved with sieve size of 128µm.

Experimental procedure

750mls of distilled water was accurately weighed into a mixing bowl and 5g of calcium was measured into the mixing bowl containing the weighed water and colorant and stirred continuously for 5 minutes. 23g of the fine snail shell powder was measured and gradually dispersed into the mixing bowl while homogeneously mixing for 5minutes. Afterwhich, 15g of titanium dioxide was dispersed and allowed to mix for 10minutes. Other ingredients in the formulation table above were serially added into the mixer.

RESULTS

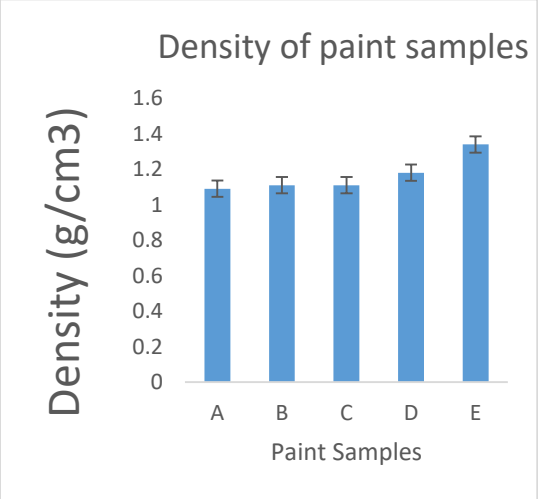

Figure 1: Density of paint samples

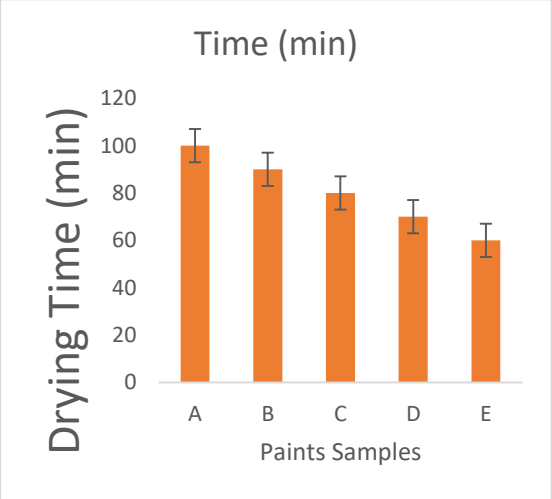

Figure 2: Dying time for Paint Samples

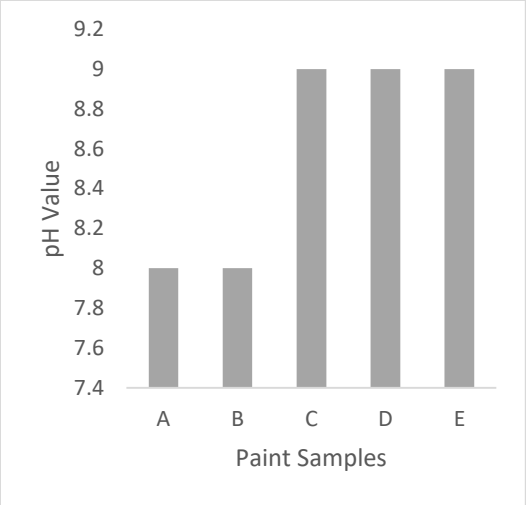

Figure 3: pH value of paint samples sample

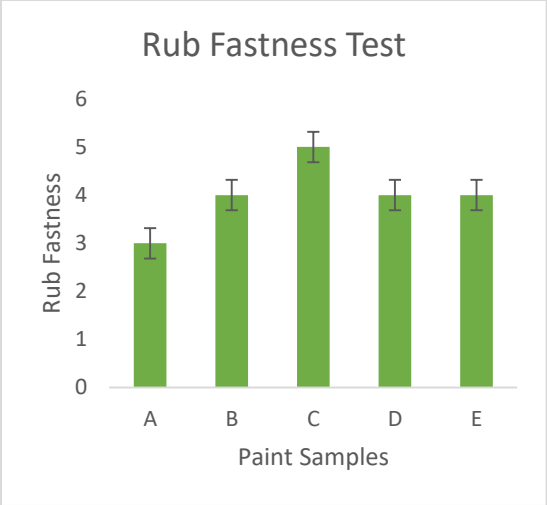

Figure 4: Rub Fastness paint for paint

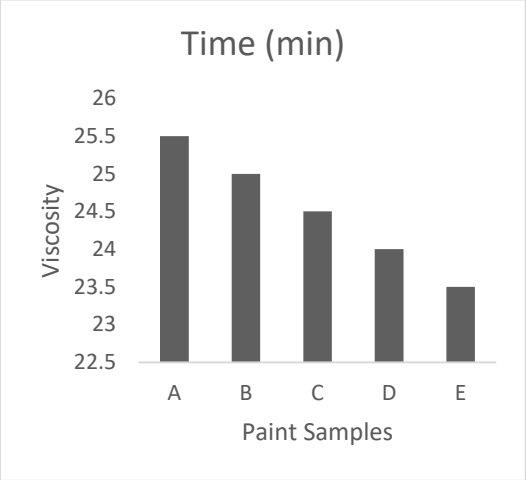

Figure 5: Viscosity paint samples

DISCUSSION

The density of the resin which was determined by taking the weight of a known volume of resin inside a beaker to obtain the mass using weighing balance. The density obtained from the paint produced as shown in Figure 1 above indicates that the densities of the paint changes with change in water contents and the binder, such that the higher the binder and the waste content the higher this may be due to the interface of the binder, solvent additives and other ingredients. The

commercial paint showed a lower density of 1.01 according to Standard Organization of Nigeria compared to the formulated paint which showed higher density.

Figure 2 shows the result of the drying time obtained between 5-10mins, when applied to the substrate and took 100mins in Sample A, 90mins in Sample B, 80mins in sample C, 70 mins in Sample D and 60mins in sample E. when 100ml of each sample was placed in an oven at 200 census to dry. The formulated paint dried much faster than the commercial paint which dried between 20-30 minutes. This revealed a good property of the paint.

Figure 3 reveals the pH level of the paint sample produced which fell within the specified range by the Standard Organization of Nigeria (SON) which is 9.0 (Rodger, 2007). From these result obtained, sample C, D and E had pH of 9 respectively. Sample A and B had pH values of 8, which is within the pH range where bacteria's strive (Jumbo, 1996). Therefore, they are susceptible to bacteria attack because of favorable environment strive three months after production except sample C, D, and E because of their high pH.

Figure 4 shows the viscosities of various paint samples, it could be seen that expanded polystyrene solution and water have effects on their viscosities, the higher the proportion of EPS and water, the lower the viscosity, the hue of appropriate paint viscosity is critical for obtaining a quality finish, excessive viscosity can cause orange peel while low viscosity can create a film that is too wet and create runs (Barley & Ollis, 2007).

The rub fastness result as presented in Figure 5. The result obtained shows that equal volume of paint covered equal surface area of leather material used for the analysis. Sample C was adjudged to have the best rub fastness while A, B, D and E had better rub fastness. However, the proportion of EPS increases in the paint Sample. It shows an increase in gray scale except Sample D and E

which the increment stopped may be as a result of the increase in water content in the paint produced.

CONCLUSION

In conclusion, from the result obtained in this study, the density, viscosity, pH, drying time and rub fastness is within the acceptable levels of requirement in the coating industry in terms of environmental safety, bacteria resistances etc.

Waste expanded polystyrene can be used as an effective replacement to PVA without compromising, standard for the production of house emulsion paint. This creates initiative for new thus providing a simple economic route for the replacement of waste polystyrene and hence an important practice for sustainable recycling. Refer to the appendices for the plates of the products produced.

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