ISSN No:-2456-2165

Sustainable Utilization of Snail Shell Powder and Marble Dust in Formulating Alkyd Paints for Industrial Applications

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Abstract:- Alkyd paints based on snail shell powder, and marble dust extenders were formulated at extender contents, 0 - 80 wt. %. Titanium dioxide (TiO_2) formulated paint served as the reference paint. The formulated paints exhibited satisfactory drying, impact resistance, and adhesion properties with the paint sample containing 60 wt.% snail shell powder exhibiting the least dry film removal of 6.25%. The sample containing 60 wt.% marble dust exhibited the best pencil hardness of 5H. The thickness of the dry paint films (0.20 - 0.30 mm) indicated the paints potentials to function as anti - corrosive paints. The paint viscosities increased with extender content, and snail shell powder formulated paints exhibited higher viscosities than those of marble dust. The paint samples containing 20 - 40 wt.% extenders exhibited high gloss that is suitable for automobile, and other consumer goods applications. The dry paint films were generally unaffected in 3% NaCl, and 3% H_2SO_4.

Keywords:- *Snail Shell Powder, Alkyd Paint, Marble Dust, Extender, Impact Resistance.*

I. INTRODUCTION

Paint extenders also, known as extender pigments are essential ingredient of paints that modify certain paint properties such as viscosity, adhesion, hardness, gloss, abrasion resistance, flow characteristics, and settling tendencies. However, they differ from true pigments because they do not impact opacity to coatings. Some commonly used extenders include talc, mica, kaolin, and feldspar [1]. Paint extenders enhance the opacity of TiO_2 by separating individual TiO_2 particles [2]. The selection and combination of extenders are thus, vital for improving both the engineering properties, and aesthetics of coatings.

Titanium dioxide, a white prime pigment is the most commonly used pigment in the coatings industry because of its efficiency in scattering white light. This property confers whiteness, brightness, and opacity to paints. The largest use of TiO_2 is in decorative coatings however, it is also, utilized in a variety of original equipment manufacturer (OEM)coatings, and industrial maintenance/ protective coatings as well, and represents approximately 31% of all pigments that are used as coatings raw materials [3]. However, TiO_2 is photo catalytically active, and contributes to photodegradation of surface coatings [4]. Furthermore, the pigment is not indigenously available, and the sourcing and processing of TiO_2 that is accompanied with material loss contributes to high cost of coating products [6][3]. Thus, paint formulators and technologists are carrying out innovative researches to partly or wholly replace TiO_2 in coatings so as to mitigate its drawbacks, and enhance the sustainability of alkyd paint production with a focus to incorporating natural and renewable extenders into coatings. There are increases in the demand for paint extenders due to advances in coatings technology**.** Paint extenders and fillers constitute the largest sub - set of pigments used in coatings, and represent approximately 56% of pigment demands in the coatings market [3]. To keep pace with demand, the following materials have been studied as potential extenders for the coatings industry: fly ash [5], silica fume [6], copper tailing waste[7] , clay[8 - 10], dolomite[11,12], industrial waste firebrick[13] , calcite, talc, barite[12,14], and granite quarry dust[15].

Marble is one of solid minerals present in abundance in Nigeria, and the mining is part of industrialization activity that provides employment for people[16] . Marble dust, a by – product of marble processing industries accumulates in large quantities at different processing sites. The dust which is non -biodegradable causes economic, and environmental problems that affect man, plants, and animals. It has been estimated that about 200 million tons of marble dust is generated worldwide by marble processing industries [17]. There is therefore, the need to handle and utilize marble dust properly for a clean and green environment. This has led to sustainable utilization of marble dust as filler in the development of innovative polymer materials [18 - 24]. Attempts to use marble waste in the construction industry have also, been reported [25 - 27]. The use of marble dust to partially replace cement will reduce the excess emission of carbon dioxide in the clinker calcination during production [28].

Snail shell is a domestic waste that results from eating the edible portion (meat) of snail. Snail meat is high in demand in Nigeria because of its health benefits and unique

ISSN No:-2456-2165

taste, and snail shell thus, can be found littering our homes, and market places due to increases in the demand for snail meat. The shells have no economic value, and are non – biodegradable. The accumulation of snail shells in our surroundings is a source of environmental pollution due to the activities of microbes and bacteria in the shells. Thus, there are efforts to develop cost – effective, sustainable, and innovative materials to utilize the abundant snail shells in our environment, and in the process, manage the waste for a clean environment. Snail shells have been investigated for such uses as the production of metal composite[29], biomaterials[30] , treatment of waste water[31] , and activated carbon[32] .

The present study reports the successful utilization of marble dust, and snail shell powder as extenders in formulating alkyd paints for industrial applications. Marble dust was collected from a marble processing outfit at Uratta, Owerri, Nigeria while snail shell powder was processed from snail shell collected from a local market at Owerri, Nigeria. The extenders were sieved to 0.075 µm particle size and incorporated into alkyd paints at extender contents, 0 – 80 wt.%. The formulated alkyd paints were characterized using standard methods. Both snail shell powder, and marble dust are wastes that are receiving attention in our laboratory in the area of applied research [33 - 36]. The utilization of these wastes in formulating sustainable alkyd paints for industrial applications is an innovative, and cost - effective method of reducing not only the cost of painting but also, offer an economic way of managing and disposing the wastes for a clean and green environment.

II. MATERIALS AND METHOD

Alkyd resin used in this study was obtained from Nicen Chemical Industry Limited, Aba, Nigeria. The extenders, marble dust was collected from Uratta, Owerri, Nigeria while snail shell powder prepared from snail shells was collected from Douglas Road, Owerri, Nigeria were sieved to 0.075 µm particle size. The driers cobalt, and lead naphthenates were purchased from a chemical shop at Onitsha, Nigeria. Cobalt drier with cobalt content, 12% was used for surface - drying of the applied paint films while lead drier with lead content, 36% was used for through - drying of the paint films.

The chemical composition of the extenders was determined using ASTM D 5381 – 94 method. Paint samples were prepared using alkyd resin (binder), marble dust or snail shell powder (extender), and xylene(solvent), and titanium dioxide (TiO_2). The prepared paint samples were characterized for dust -, and through – dry times, dry paint film thickness and hardness, adhesion of dry paint films to mild steel panels, impact resistance of dry paint films, and resistance of dry paint films to 3% HCl, 3%NaCl, 3% NH_3, and 3% C_4H_9OH using methods as described previously[37,38]. The viscosity of the paint samples was determined using a rotational viscometer while the gloss (60°) of dry paint films was determined in accordance with ASTM D 3928 - 00 method.

III. RESULTS AND DISCUSSION

➤ *Oxide Composition of the Extenders*

The metallic oxide analysis shows appreciable quantities of calcium oxide (81.67%), and aluminum oxide (2.0%) in snail shell powder, and for marble dust, the major oxides present are calcium oxide (69.33%), silicon oxide (7.73%), and aluminum oxide (1.56%). The other oxides are present in small proportions. The presence of unreactive oxides in the extenders is indicative that paints formulated with them will function as anti – corrosive paints capable of slowing down the diffusion of corrosive species into the applied paint film thereby, delaying the phenomenon of corrosion with aluminum oxide impacting hardness to coatings.

➤ *Characterization of Formulated Paint Samples*

- *Surface - Dry Time*

Figure 1 shows the effects of extender type, and content on the surface - dry times of the formulated paint samples. The paint sample without an extender had surface dry time of 105 min. With the exception of paint samples containing

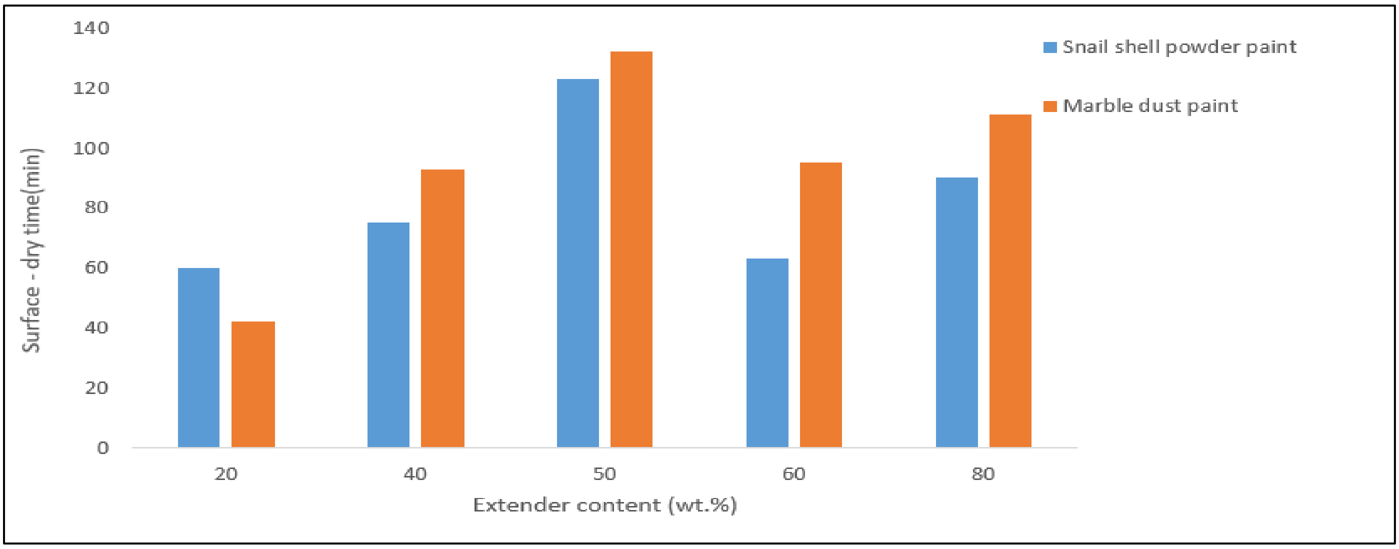

Fig 1 Effect of Extender Content on Surface - Dry Times of Prepared Paint Samples.

50 wt.% snail shell powder, and marble dust, and 80 wt.% marble dust that had surface dry times above 105 min, all the other formulated paint samples had surface - dry times below 105 min. The 20 wt.% snail shell powder, and marble dust formulated paint samples exhibited the least surface - dry times of 60, and 42 min respectively. Generally, the marble dust formulated paints exhibited higher surface - dry times than snail shell powder formulated paints. The surface - dry times of the paint samples satisfied the Nigerian Industrial Standard (NIS) requirement that stipulates that the surface - dry times of a gloss paint shall not exceed 6 h from time of application.

- *Through - Dry Time*

Figure 2 illustrates the effects of extender content, and type on the through - dry times of the formulated paint samples. The through - dry time of the paint without an extender is 225 min. The incorporation of the extenders generally.

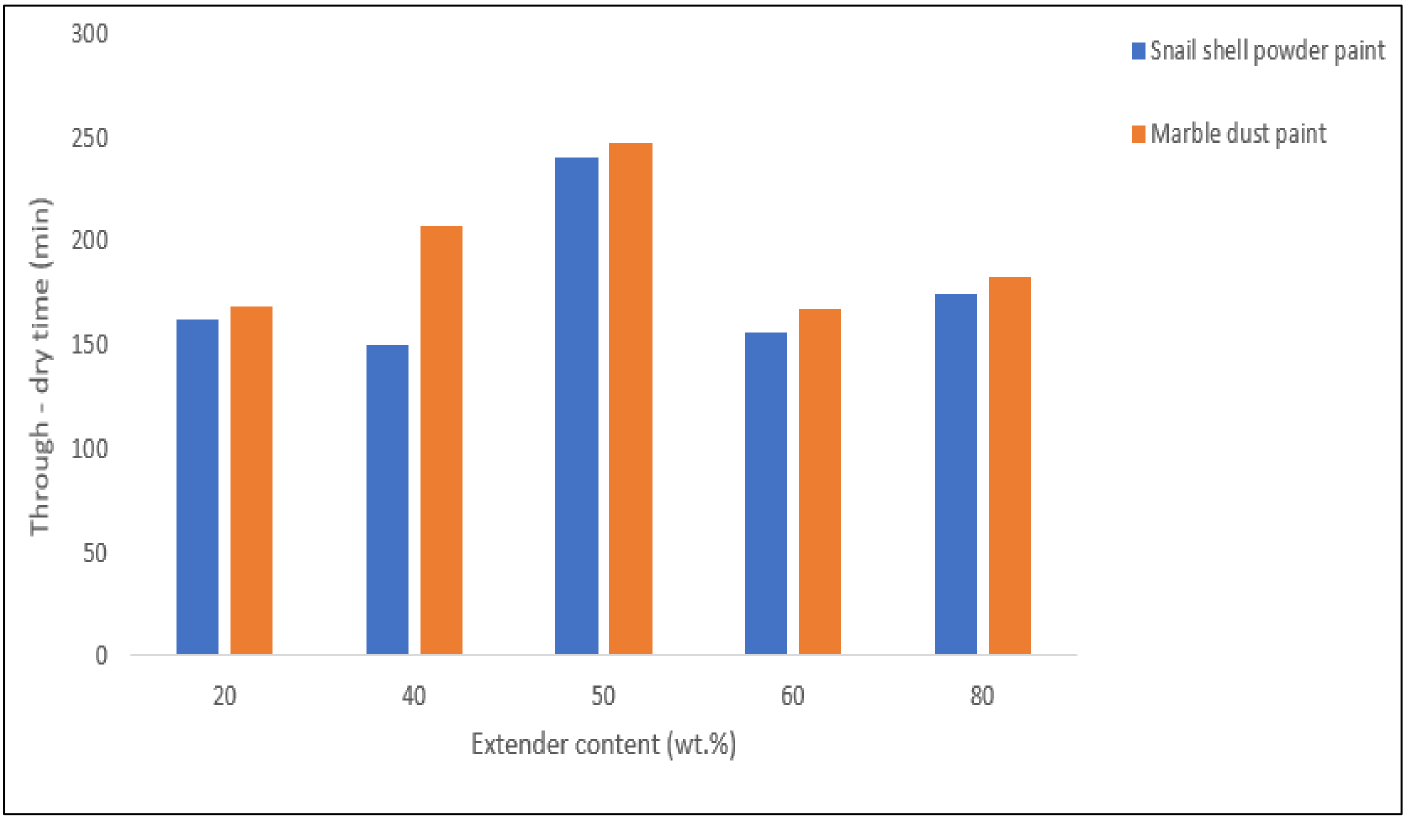

Fig 2 Effect of Extender Content on through - Dry Times of Prepared Paint Samples.

Decreased the through - dry times of the paint samples with the exception of paint samples containing 50 wt.% snail shell powder that had through dry time of 240 min, and 50 wt.% marble dust that had through - dry time of 247 min. The paint sample containing 60 wt.% snail shell powder exhibited the least through - dry time of 156 min while the marble dust formulated paint containing 60 wt.% marble dust exhibited the least through - dry time of 167 min. The through - dry times of marble dust formulated paints increased with marble dust content up to 50 wt.% marble dust thereafter, decreased at 60 wt.% marble dust content, and increased again at 80 wt.% marble dust content. The through - dry times of snail shell powder formulated paints did not show any order of variation with extender content. The through - dry time of the paint samples satisfied the NIS requirement that a gloss paint shall have maximum through - dry time of 24 h from the time of application.

- *Impact Resistance*

The extender formulated paints passed the impact resistance (impact strength) test which attested to their good quality. The impact resistance of a paint film is an integral part of the protective function of the film, and can be used to ensure that it can withstand various mechanical shocks in actual use without damage.

- *Dry Paint Film Thickness*

The effects of extender type and content on the film thicknesses of applied paint samples are illustrated in Figure 3. The dry paint film thickness of the paint without an extender is 0.25 mm, and which is the same as the dry.

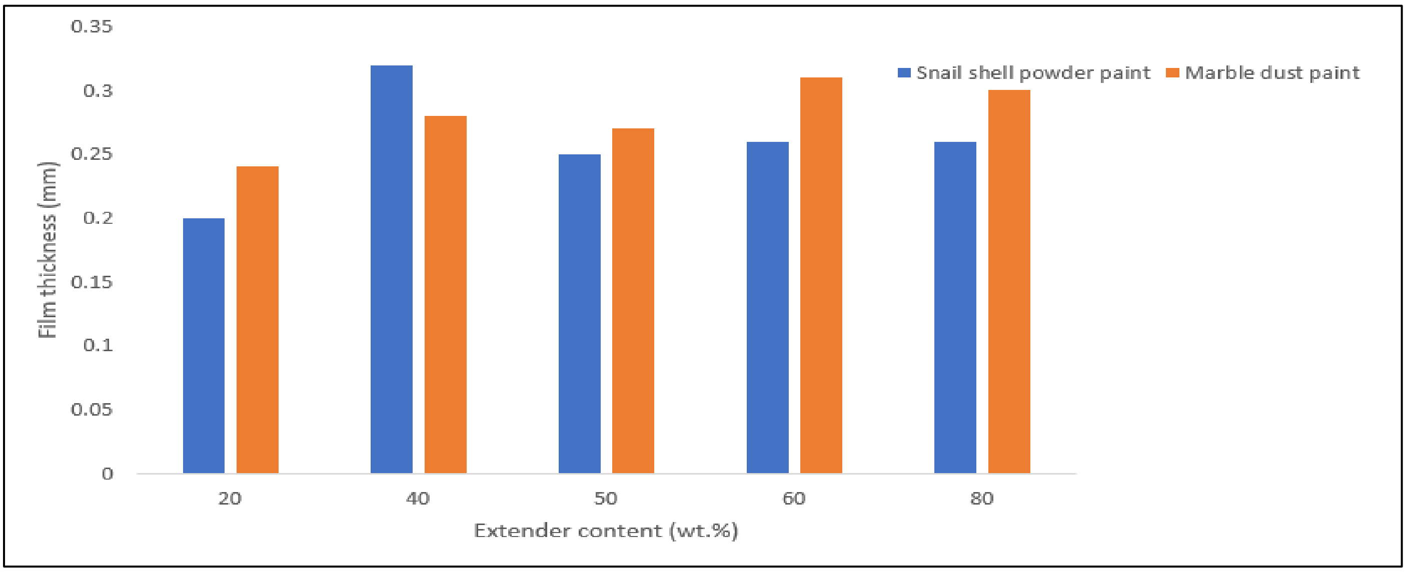

Fig 3 Effect of Extender Content on Dry Paint Film Thickness of Prepared Paint Samples.

Paint film thickness of the 50 wt.% snail shell powder formulated paint. The 20 wt.% snail shell powder formulated paint exhibited the lowest film thickness of 0.20 mm while the 40 wt.% snail shell powder formulated paint exhibited the highest film thickness of 0.32 mm. In general, the snail shell powder formulated paint samples exhibited lower dry paint film thickness compared to marble dust formulated paint samples. The thickness of the dry paint films generally lie between 0.20 and 0.31 mm, and did not show any definite order of variation with extender content. A film thickness of more than 20 μm performs well as a barrier resistant to weathering [39].

- *Adhesion Test*

The adhesion property of the prepared paint samples to mild steel surfaces are illustrated in Figure 3.4. The formulated paint sample without an extender exhibited 12.50% adhesion loss of film removal from mild steel surface. Snail shell powder formulated paint containing 40 wt.% snail shell powder exhibited minimum adhesion loss of 6.25% while the paint containing 60 wt.% snail shell powder had maximum film removal of 25%. On the other hand, marble dust formulated of paints containing 20, and 80 wt.% marble dust exhibited minimum adhesion loss of 12.50%, and which is the same as that of the paint sample without an extender. The paint sample containing 50 wt.% marble dust had 25% adhesion loss of film removal from mild steel surface, and which is the same as that of 60 wt.% snail shell formulated paint. The adhesion property of marble dust formulated paints increased within extender content 20 – 50 wt.%, and thereafter, decreased at 60, and 80 wt.% marble dust content. According to Nigeria Industrial Standards (NIS) [40], an oil (gloss) paint shall have 50% maximum film removal from painted surface. Generally, the incorporation of the extenders into the paints did not have adverse effect on the adhesion property of the formulated paints as the paints satisfied the NIS requirement on oil paint film removal from painted surfaces. The good adhesion property of the paint films is an indication that the formulated paints should be able to protect painted surfaces from mechanical damage, and thus, corrosion of metallic surfaces. Coated surfaces are normally removed in service from agents such as chipping, abrasion, corrosion of substrates, impingement by stones, etc.

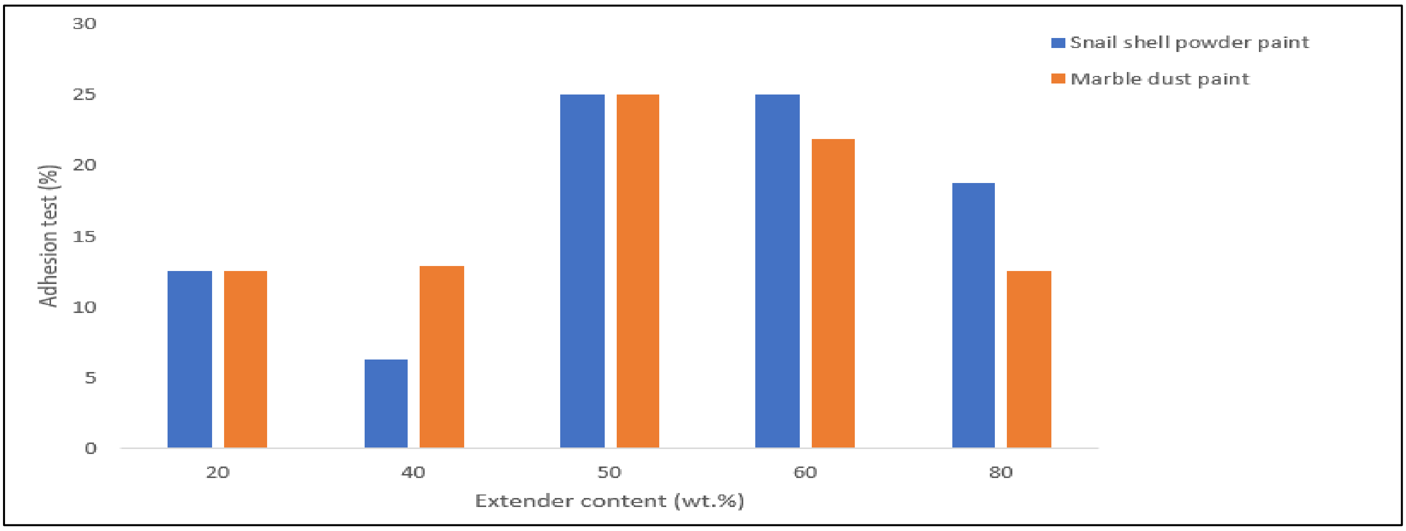

Fig 4 Effect of Extender Content on Adhesion to Surfaces of Prepared Paint Samples.

- *Paint Viscosity*

Data on the viscosity of the formulated paint samples are illustrated in Figure 5. The pant sample without an extender exhibited the least viscosity of 17.30 poise. The viscosity of the paints generally increased with extender content, and were in all cases higher than that of the paint without extender. Snail shell powder formulated paints exhibited higher paint viscosity than marble dust formulated paints except at the extender content, 50 wt.%. The highest paint viscosity (58.96 poise) was recorded for snail shell powder formulated paint at extender content, 50 wt.%.

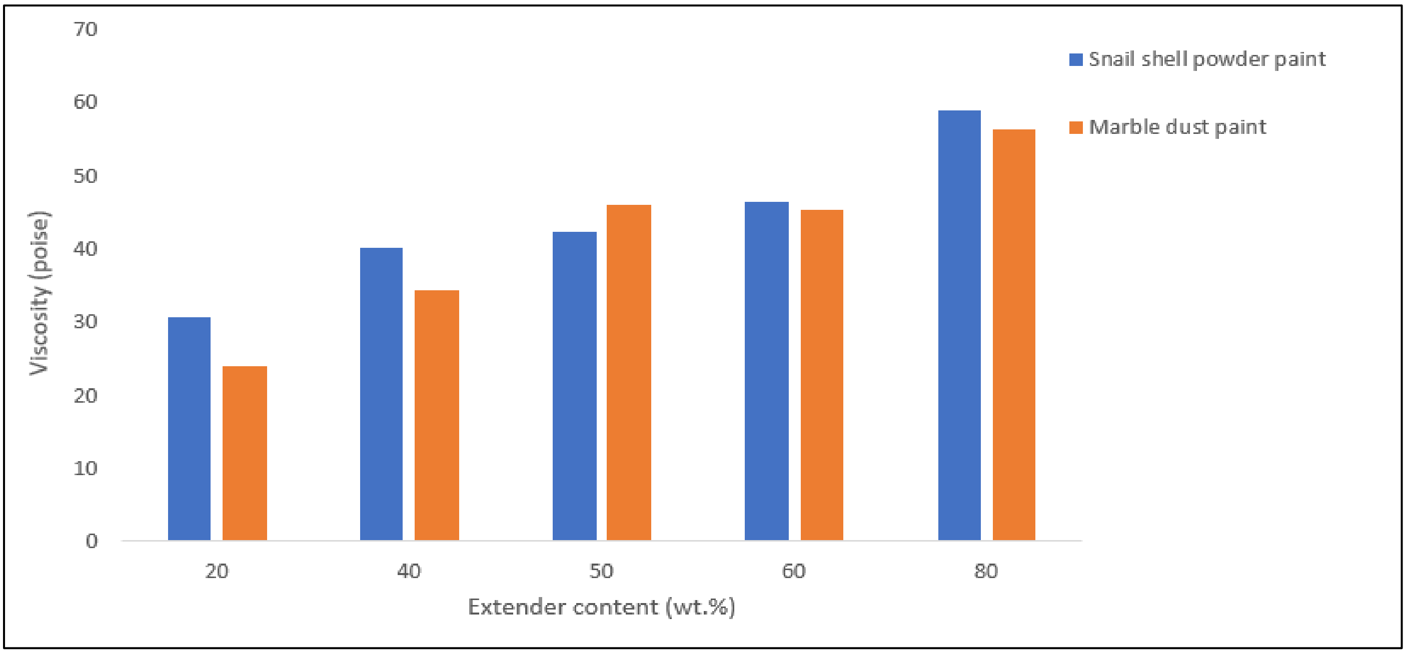

Fig 5 Effect of Extender Content on Viscosity of Prepared Paint Samples.

- *Paint Gloss*

The gloss (60°) of the formulated paint samples is illustrated in Figure 3.6. The gloss of the paints generally decreased with extender content, and were generally lower than the gloss of the paint without extender (76.10 GU). The gloss of the formulated paints at extender contents, 20 – 50 wt.% generally lie between 70.0 and 75.9 GU, and are high with a reflective appearance suggesting that the paints can be utilized in the automobile industry. The gloss of 80 wt. % extender formulated paints is of low sheen while those of 60 wt.% formulated paints are glossy.

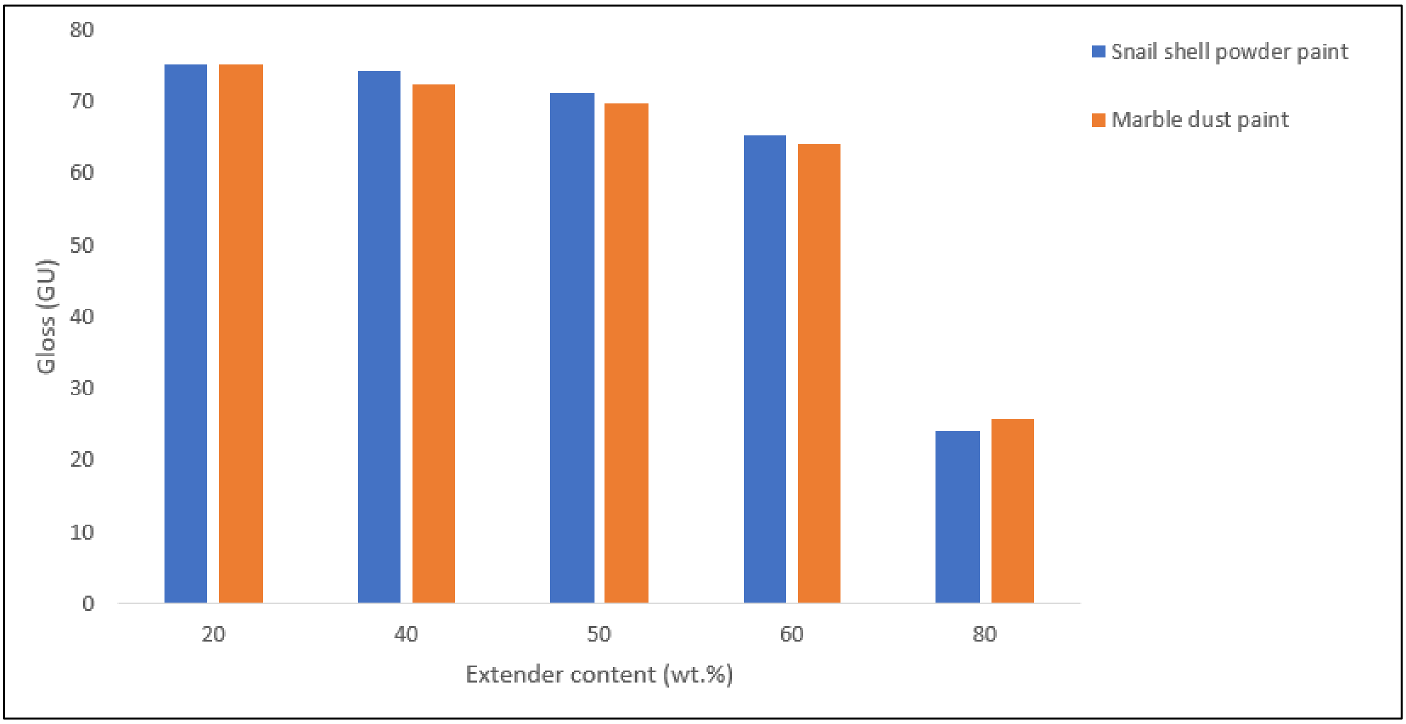

Fig 6 Effect of Extender Content on Gloss (60°) of Prepared Paint Samples.

ISSN No:-2456-2165

- *Dry Paint Film Resistance to Chemicals*

The prepared paint dry films performed satisfactorily after immersion in 3% HCl, and 3% NaCl with few formulations exhibiting slight colour change. This is an indication that the paints can function as perform well in acidic and alkaline environments. The good performances of the paint samples in the chemical media studied is attributed to the presence of the inert oxides contained in the extenders which will slow down the diffusion of corrosive species into the film substrates thereby, enhancing corrosion resistance of the films.

IV. CONCLUSION

Snail shell powder, and marble dust were successfully utilized to formulate alkyd paints with improved properties. The surface -, and through - dry times of the formulated paints were satisfactory. The paint viscosities increased with extender content, and maximum viscosities were obtained for snail shell powder formulated paint (58.96 poise), and marble dust formulated paint (56.40 poise) at 80 wt.% extender content. The formulated paint samples passed the impact resistance (strength) test, exhibited good adhesion to mild steel substrates with the paint sample containing 60 wt.% snail shell powder exhibiting the least dry film removal of 6.25%. The dry paint film thicknesses were in the range, 0.20 – 0.30 mm, an indication that the paints will function as anti-corrosive paints. The prepared paint samples exhibited high gloss at extender contents, 20 - 50 wt.%, and which are suitable for applications on automobiles, and other consumer goods. The paint samples exhibited better hardness than the sample without extender (3B), and the sample containing 60 wt.% marble dust exhibited the highest hardness of 5H. The dry paint films were generally unaffected after immersion in 3% HCl, and 3% NaCl, an indication that the paints will perform well in these environments.

The present study has demonstrated the utility of snail shell powder, and marble dust as extenders in formulating alkyd paints for industrial applications. The expectation is that these extenders which are waste should find utilization in the surface coatings industry, and which will help to reduce the over dependence on imported pigments thereby, saving the country the scarce resource spent on importation. Fortunately, the waste is easy to process, and are available for exploitation.

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