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INTEGRATED EMULSION PAINTS DERIVED FROM THREE POLYVINYL ACETATE (PVA) GROUNDNUT OIL

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ABSTRACT

A modified paint was produced in this research to supplement and substituteproducts by tender small-scale private paint factories, in an era of increasing demand of paints by the nation's alarmingly growing building technology. The research was aimed at the formulation of an emulsion paint with the aid of polyvinyl acetate mixed with Groundnut oil as a binder by reducing volatile organic compounds and to determine the major physical parameters such as drying time, period of elongation, density, refractive index, adhesion, pH, and chemical resistance. The result obtained showed increase of dry to hard from Pure PVA paint (90.23 minutes) followed by Gombe PVA paint (105.5 minutes) to Taraba PVA paint (110.00 minutes). The drying time of the paint samples was in this order Taraba PVA paint (80.0 min) > Gombe PVA paint (75.5 min) > Pure PVA paint (75.23 min). The dry to touch was in the decreasing order: Taraba PVA paint (56.2 min) > Gombe PVA paint (53.4 min) > Pure PVA oil (49.15 min). The density (g/cm^3) showed that Gombe PVA paint (1.16) > Pure PVA paint (1.30) > Taraba PVA paint (1.10). The solubility test for both Taraba PVA Groundnut paint and Gombe PVA Groundnut derived paint are practically insoluble in water, while Pure PVA derive paint dissolved in water instantly. All the three formulated paints passed the resistance blistering and flexibility tests. FTIR showed the following functional groups Hydroxyl, Amines, Carboxylic acids, Alkylhallides, Ketones and Aldehydes at specific wavelength are present in paints that serves as co-binders in the fabricated paints. Parameters investigated for the three formulated paints showed that they fall within the required standard, and that can substitute for industrial paints. The paints investigated demonstrated effective promotion fight against atmospheric and chemical variations compare standard paints.

Keywords: Emulsion paints, Substitute, Binder, Groundnut oil, Derived paint

INTRODUCTION

Applications of paint to a surface coating is the most protective and attractive measures on any material that is used constantly smeared as a thin continuous layer of expose bodies (Ghasemlou *et al*., 2024). Paint was conventionally utilize to clear films which are more appropriately called glosses or finishes as reported by Surajudeen *et al*.,(2015).

Paint is a combination of pigments, binders and solvent that forms a constant film that can be decorative or protective to a surface (Kumar *et al*., 2024). The combination of binder and volatile liquid is known as the mixture; it can be collided gel or spreading of the fine binder's particles in a non-solvents. The term coating denotes to a progressive or particular paint formulated to have a specific function relating more to a shielded layer rather than serving as ornamental object of the substrate (Heath, 2017). When an emulsion paint is applied to a surface, the volatile part of the main constituents evaporates, whereas the thick precipitate binder-pigment gluey as residual film, which undergoes chemical reactions to form a solid state object (Bergenbrink, & Billstein, 2022). In order to improve the application of pigments settling, drying qualities of a paint, negligible quantity of additives is required and film formations. Most binders are often high molecular weight, non-reactive organic polymers or low to medium molecular weight, reactive polymer capable of being further polymerized via chain extension or cross linking reactions to high molecular weight films (Onoja *et al*., 2019). Therefore, this study was aimed at the formulation of an emulsion paint with the aid of polyvinyl acetate mixed with Groundnut oil as a binder by reducing volatile organic compounds and to determine the major physical parameters such as drying time, period of elongation, density, refractive index, adhesion, pH, and chemical resistance.

MATERIALS AND METHODS

Sample Collection

Three type of Groundnut oil such as Pure Polyvinyl acetate (PVA), polyvinyl acetate that was purchased from oil stock marketers at Nasarawa quarters, Gombe. (PVA) Gombe Groundnut oil and Polyvinyl acetate (PVA). Taraba Groundnut oil were purchased directly from oil millers at each located town and kept in clean plastic bottles as adopted by Yelwa *et al*., (2017).

Paint Formulation Analysis

The method described by Lawal *et al.,* (2019) was adopted for paint formulation. Exactly 250 cm^3 of clean water was poured into a liter combination tank, then 20 cm^3 of a deformer, was added to the mixture at certain time intervals of two minutes until it was finished; a stirrer was inserted in to the tank for proper mixing. After stirring, 10 g of Rutile (TiO_2) plus 10 g of kaolin with off-white colour was then added; at the same time of 30 g of (limestone), $CaCO_3$ was added immediately. The content were allowed to settle for 2 minutes then 30 cm^3 of formulated Polyvinyl Acetate (SBO) binder, plus 20 cm^3 of formalin, plus 4 g of cellulose. Ether mixed with 20 cm^3 of distilled water were poured all together.

The final additives poured into the mixture was 10 cm^3 of ammonia solution was incorporated. The required ingredients were organized and poured one after the other at certain intervals of not less than 10 minutes, each addition with constant stirring to an anticipated uniformity. The mixture of the raw materials content of the paint in the mixing tank or

container was made up to 500 cm^3 mark level with distilled water.

Evaluation of Derived Paints

pH Analysis of Paints

The pH values of formulated paints samples derived from polyvinyl acetate groundnut oil was examine and recorded by inserting the electrodes of digital pH meter. The pH meter electrode tips were sterilized with a solution of buffer 7.0 and wash two times to remove dirts with distilled water. Then electrode end of the meter was carefully inserted into the paint sample container and allowed to settled and calibrated, then pH of the paint was examine and recorded (Lawal *et al*., 2019).

Chemical Inhibition of Derived Paints

The determination of chemical resistance of the derived paint films formulated, was conducted by three flexible aluminum panels with portable size of (150 mm x 0.3 mm) were castoff as the test panels. A thin coating of paint layer with paintbrush was spread on the panel as tested samples. Then a glass beaker with a capacity of 1000 $cm^3$was filled to mark with 0.1M NaOH solution that possesses a depth of 150 mm and the test piece of aluminium panel were immersed into the container and at the depth of approximately 120 mm and allowed for 48 hrs. that reacted. The tested pieces of panels was removed and cleaned with distilled water instantly to remove impurities and placed on a clean surface to dry for 2 hrs. The method adopted was equally repeated by using a mixture of 0.1M HCI and 0.1M NaCl respectively. The presence of any surface defects such as cracking, blistering, peeling or change in color indicates poor chemical resistance as adopted by Lawal *et al.*, (2019).

Resistance to Blistering

Resistance to blistering of the derived paints sample was investigated with respect to the derived paint sample was spread on a glassy panel with the paint brush which expose a wet film thickness. The content of the mixture on investigation was allowed to dry in undirected sunlight for 2 days. After drying, then 4 cm^3 of distilled water in the form of circular drop was flushed on the surface of the coated film originated from immersion process. The result showed appearance of several blisters, wrinkling and swellings due to outrageous within a period of 30 minutes appeared during drying process that specified less water proof ability of the paints. Quality assessment of the derived paints recorded the effective adaptations as required by determinations of each sample as adopted by Fadawa *et al*., (2018).

Drying Time

The drying time of the paint samples produced was evaluated according to the required standard method (Fadawa *et al*., 2018).

Dry to Touch and Dry to Hard Test

Methods of dry to touch and dry to test properties of the derived paint samples was investigated in accordance to standard technique according (2018).

Flexibility Test of Derived Paints

Flexibility test of the derived paints was analyzed according to modern technique method. Derived Paint sample was spread on aluminium panel with the application of paintbrush. The film of the coated paints was left for air dry under room temperature (27^oC) for a maximum of 7days. The panel coated with the paint film was then applied force that bent through 180^o using a smooth action within 1-2 seconds interval. The panel was then released which returned to its initial position as adopted by Fadawa *et al*., (2018).

Fourier Transformation Infra-Red Spectroscopy Analysis

FTIR analyses of the paint sample was carried out. The result depend on the absorption coefficient and particle size of the investigated samples as adopted by Usman *et al*., (2019).

Solubility of Derived Paints in water

Solubility of the resins of pains in water was determined by mixing 1ml of the resin with 5ml of distilled water at room temperature range of 27-30°^{C} as adopted by Uheine *et al*., (2024).

Density of Derived Paints

Density of sample paints was investigated by recording the mass of a standard quantity of resin inside a density instrument using metler (Model, AT400) electric balance. Average value of five readings were taken for each sample and later a calculated mean was recorded as density of paint under investigation as reported by Fadawa, *et al* (2018).

RESULTS AND DISCUSSIONS

Physicochemical Properties of Derived Paint Samples

The outcomes of some tested physicochemical parameters qualities of a derived paint samples investigated using Groundnut oil from Gombe and Taraba as modifier polyvinyl acetate as co-binders were describe as follows.

Drying Time of Derived Paints

Figure 1 present the drying time of paints sample, Where Sample three is pure polyvinyl Acetate (PVA) Ground nut oil from Taraba showed 80.0 minutes drying time followed by Gombe pure polyvinyl Acetate (PVA) Ground nut oil with 75.5 minutes drying time, while Pure pure polyvinyl Acetate (PVA) showed the least drying time of 70.23. The result obtained in this research indicate that the drying time is similar to the findings of Fadawa, *et al*., (2018).

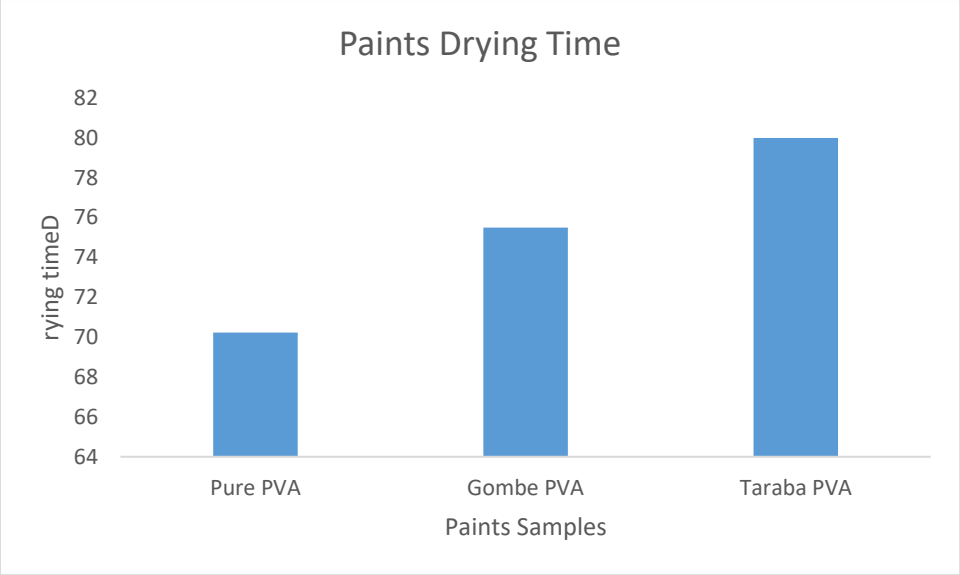

Figure 1: Drying Time of Paints

Flexibility

The flexibility test of the formulated paints in the study showed that all the three samples Pure PVA, Gombe PVA Groundnut oil derived paint, and Taraba PVA Ground nut oil derived paint passed the flexibility test with high percentage flexible. These result showed correct efficiency as reported by the investigations of Fadawa, *et al*., (2018).

Solubility of Derived Paints

The solubility test of the manufactured paints in this study showed that only that sample of Pure PVA had perfect solubility in water, while Gombe PVA Groundnut oil derived paint, and Taraba PVA Ground nut oil derived paints were completely insoluble in water due to the oil content in the samples. The result investigated is synonymous with the findings of Fadawa *et al*., (2018). Solubility effect of the formulated paints showed lower concentrated paint with 5g and 10g are soluble in water while 15g sample was partially soluble and 20g and 25g paints samples are practically insoluble in water as reported by Uhiene *et al*., (2024).

Dry to Touch of Derived Paints

Dry to touch of paints samples was investigated as indicated in Figure 2 as the duration of the paints ingredients combination and unity that inspired solvent evaporated which showed increase in the drying to touch from range Pure PVA (49.15) < Gombe PVA (53.4) < Taraba PVA (56.2). The result obtained is similar to the findings of Fadawa, *et al.*, (2018). However, the result is contrary to the 20.0 – 25.0 minutes dry to touch properties of the paints samples investigated by Uhiene *et al*., (2024).

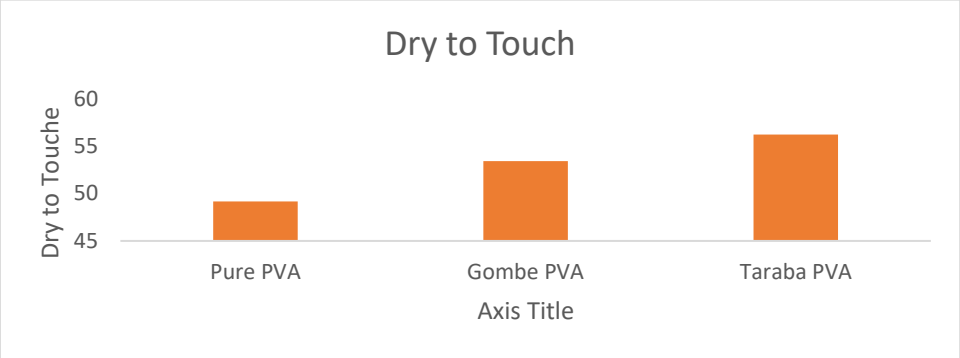

Figure 2: Drying to Touch of Paints

Dry to Hard

The result obtained showed increase of dry to hard from Pure PVA (90.23) minutes followed by Gombe PVA (05.5) minutes to Taraba PVA (110.00) minutes which was synonymous to findings of Fadawa *et al*., (2018). In addition, the result obtained was contrary to dry to hard of investigated paints of 85 to 95 minutes as reported by Uhiene *et al*., (2024).

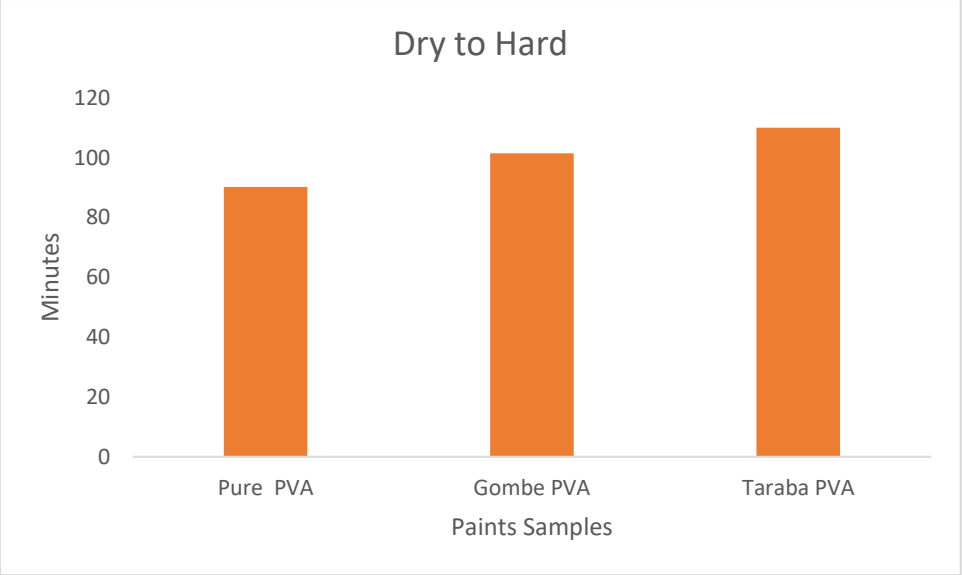

Figure 3: Hard to Touch of Paints

Density

The result of density measurements for the three PVA, Ground nut showed decrease in density ranging from Pure PVA paint (1.45) < Gombe PVA paint (1.30) < Taraba PVA paint (1.10) g/cm^3 ·This is attributed to fact that decrease in volume of the paint samples. This implies that there was increase-exaggerated volume of the paint than the mass of the concentration of the Groundnut oil paint, which increases as reported by Fadawa *et al.*, (2018). The minimum approved density of standard paint is 1.01 gcm^{-3}. Whereas the density falls within the range of 1.10 to 1.45 gcm^3 of the derive paints in this study is synonymous to the density of 1.34 gcm^{-3} as reported by Uheine *et al*., (2024).

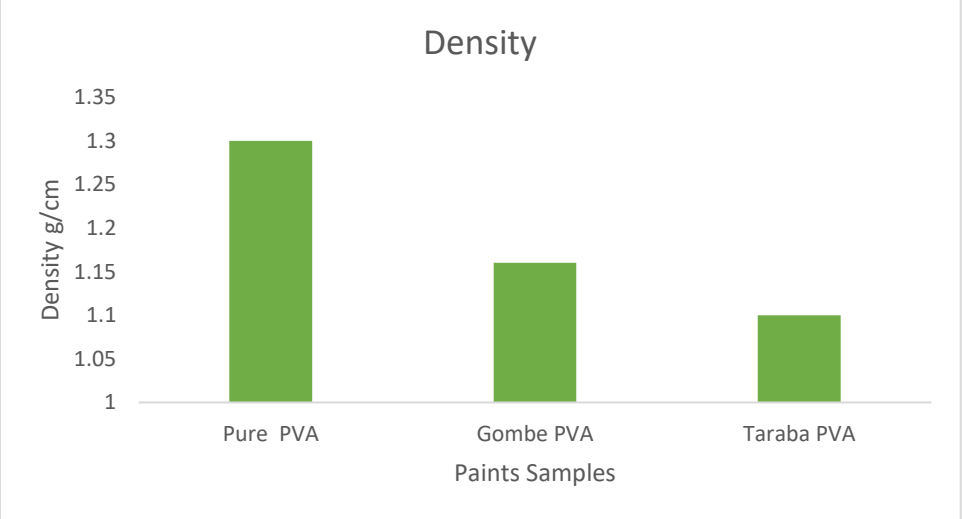

Figure 4: Density of the paint sample

pH Values

The results of pH values of the three sample of paints are displayed in Figure 5. The result showed Taraba PVA Groundnut oil formulated paint has the highest pH value of 11.18 followed by Gombe PVA Groundnut oil formulated paints with value of (11.16) and Pure PVA oil formulated paint had the least value (11.18). All the three sample oil observe for paint formulation existed in alkaline condition, the result obtain are within the accepted level required in the coating industry as reported by Lawal *et al.*, (2019). The result of pH values obtain is contrary to the findings of Surajudeen and Zebulu (2015) that showed Samples B, C, D, E and F developed paints had pH range of 7.27 to 7.62 only.

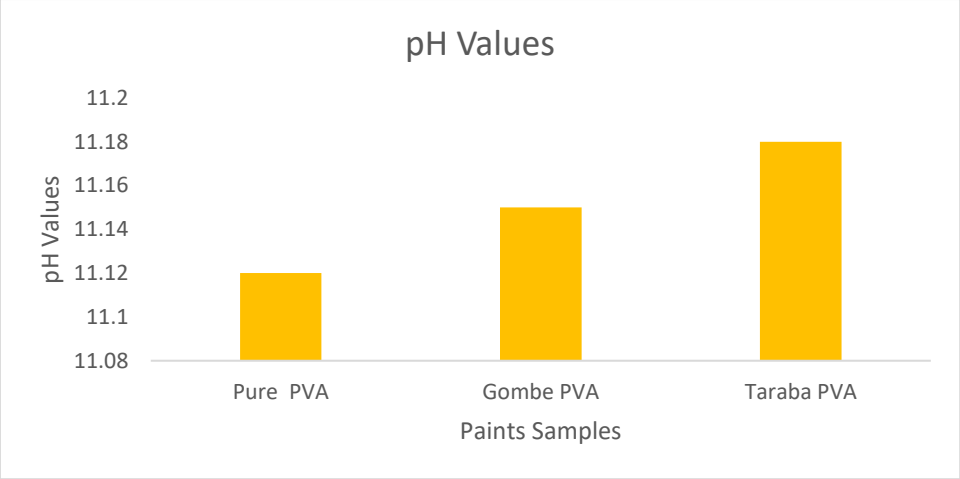

Figure 5: The pH Values of paint Samples

Resistance to Blistering

The outcome of blisters formation and water proof adherence of the three different derived paint samples formulated which observed that paint has effective resistance to blistering test. The result revealed that Ground nut oil part has been cross coupled in to the Poly vinyl acetate Ground nut oil copolymer this making the result displaying hydrophilic property which help in to escalation the water resistivity of the derived paint creation. The result obtain passed the blistering properties was similar with the findings of Fadawa *et al.*, (2018) and synonymous to the findings of Uheine *et al*., (2024).

Chemical Properties of the Derived Paints

Results and assessment of chemical resistance of pure PVA paint, Gombe PVA Groudnut oil derived paint and Taraba PVA Groundnut oil derived paints presented the effective reactivity of the three common mediums such as ionic (NaCl), alkaline (NaOH), and acidic (HCl) within their surface layered in conjoined the paints sample. Derived paint samples showed no consequences; thus it serves a better resistance to this mediums, with contradiction to Pure Groundnut oil derive paint, which blisters in the alkaline medium. The result obtain was similar to work of Lawal *et al*., (2019).

Table 1: Chemical Properties of Paints

SN	Sample	0.1 m NaCl	0.1m HCl	0.1m NaOH
1	Pure PVA	Permit	Permit	Poor
2	PVA/G/nut from Gombe	Permit	Permit	Poor
3	PVA/G/nut from Taraba	Permit	Permit	Poor

FTIR Values of Pure PVA

The outcome of FTIR investigations showed in Figure 6 which, exhibited functional group present in Pure PVA oil derived paints. The result revealed: O-H (3500-3410 cm^{-1}), N-H stretch (3426.12 cm^{-1}), C-H stretch (3195.18 cm^{-1}), H-C=O:C-H stretch (2940.95 cm^{-1}), C-N stretch (2329.71 cm^{-1}) -C=C-stretch (2014.46 cm^{-1}), N-H bend (1689.08 cm^{-1}), C-H bend (1444.91 cm^{-1}), C-N stretch (1108.12 cm^{-1}), C-Cl stretch (774.25 cm^{-1}) C-H rock (713.58 cm^{--1}). The result showed common functional group present was almost related to functional group present in edible crops as reported by the findings of Usman *et al*., (2019). Also the result obtain showed synonymous functional groups of O-H, C-H, C-O, C-H, C=C, C=O present as reported by Ibrahim and Abdullahi (2024)

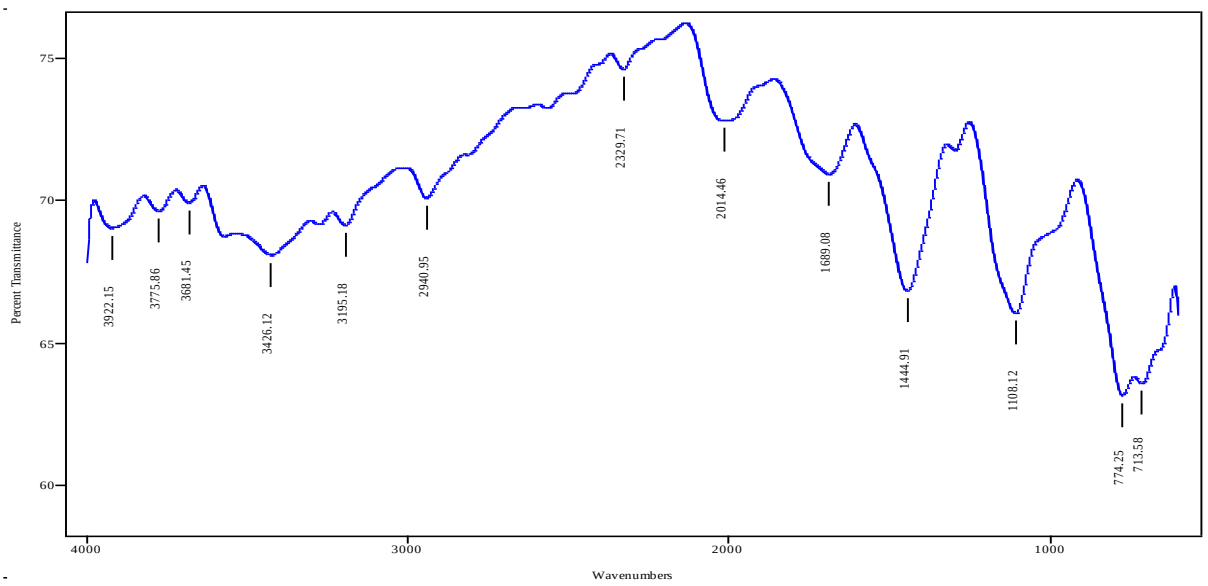

Figure 6: FTIR of Pure PVA

FTIR Values of Taraba PVA

Figure 7 indicated FTIR values of some functional group present in Taraba PVA oil derived paints. The result showed that O-H stretch, free hydroxyl (3726.72 cm^{-1}), O-H stretch-bonding (3554.63cm^{-1}),N-H stretch (3380.89 cm^{-1}), -C=C-H:C-H stretch (3277.58 cm^{-1}), H-C=O:C-H stretch (2927.01 cm^{-1}), C=N stretch (2267.83 cm^{-1}), -C=C- stretch (1993.28 cm^{-1}), C=O stretch (1735.93 cm^{-1}) ,C-H bend (1451.93 cm^{-1}), C-N stretch (1167.40 cm^{-1}), C-H bend (1084.97 cm^{-1}), O-H bend (967.32 cm^{-1}), C-H rock (721.88 cm^{-1}). The result obtain was related to the work done on functional group present in edible crops as reported by Usman *et al*,. (2019) and also synonymous to the functional groups of O-H, C-H, C-O, C-H, C=C, C=O present as reported by Ibrahim and Abdullahi, (2024).

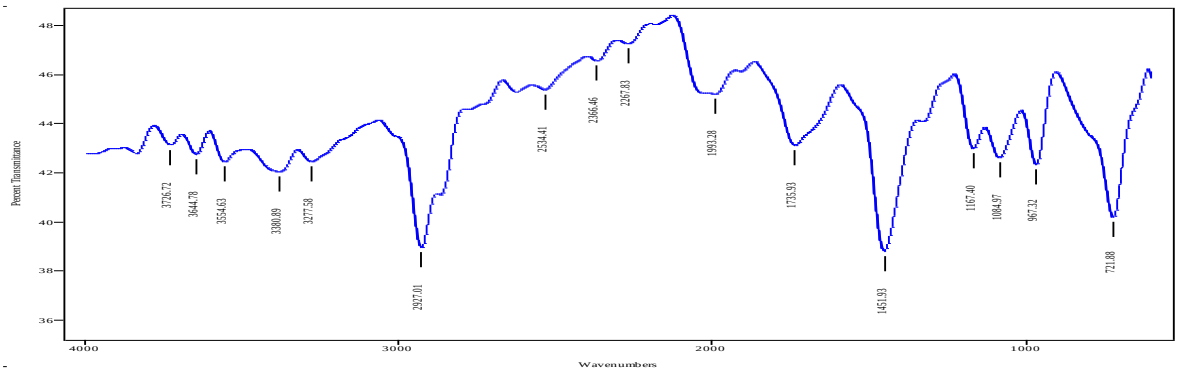

Figure 7: FTIR of Taraba PVA

FTIR Values of Gombe PVA

Figure 8 indicated that the FTIR of Gombe PVA which showed the presence of the functional groups: O-H stretch, free hydroxyl (3612.55 cm^{-1}), O-H stretch, H bonded (3455.48cm^{-1}), O-H stretch (3384.94cm^{-1}), -C=C-H:C=H stretch (2536.02cm^{-1}), C=O stretch (1742.98cm^{-1}), C-C stretch (in ring) (1455.80cm^{-1}), C-H wag(-CHX) (1258.63cm^{-1}), O-H bend (971.75cm^{-1}), C-Cl stretch (726.13cm^{-1}). The functional group present in paints were almost related to the functiona groups present in edible crops as reported to the findings of Usman *et al*., (2019) are also synonymous to the work of Fadawa *et al*., (2018). The result investigated was ynonymous to the functional groups of O-H, C-H, C-O, C-H, C=C, C=O present in Doum Palm as reported by Ibrahim and Abdullahi, (2024).

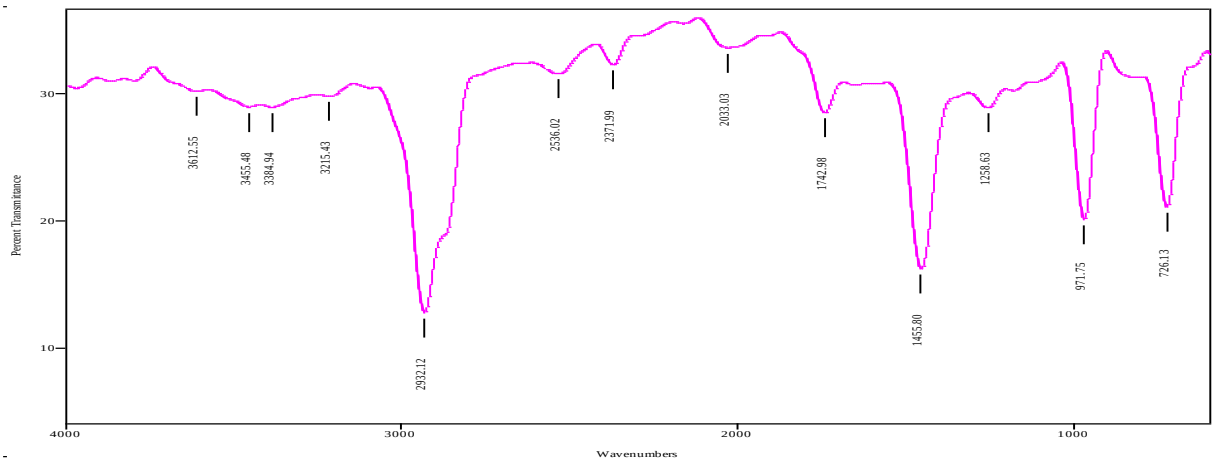

Figure 8: FTIR of Gombe PVA

Comparative Values FTIR of Three Analyzed PVA

Figure 9 showed the common functional group presence were predominantly oxygen compounds due presence of the carbonyl group with oxygen that play role of oxidizing the paints. The hydroxylation of the Groundnut presents a hydroxyl group on the oil nature of raw material. At the peak at 3449 cm^{-1}. The C = O stretching in the oil resulted to inert association with the rocking vibrational bending from C – H bond from a methyl alkane occurred. At 1098 cm^{-1} CO – O – CO stretching from anhydride. The functional groups present in derived paints were similar to the functional groups present in edible crops as reported to the findings of Usman *et al*,. (2019) are also related to functional groups investigated by Uhiene *et al*., (2024) .The result obtain was contrary the findings of functional groups present in Doum Palm as reported by Ibrahim and Abdullahi, 2024 were CO-O-CO anhydride was absent.

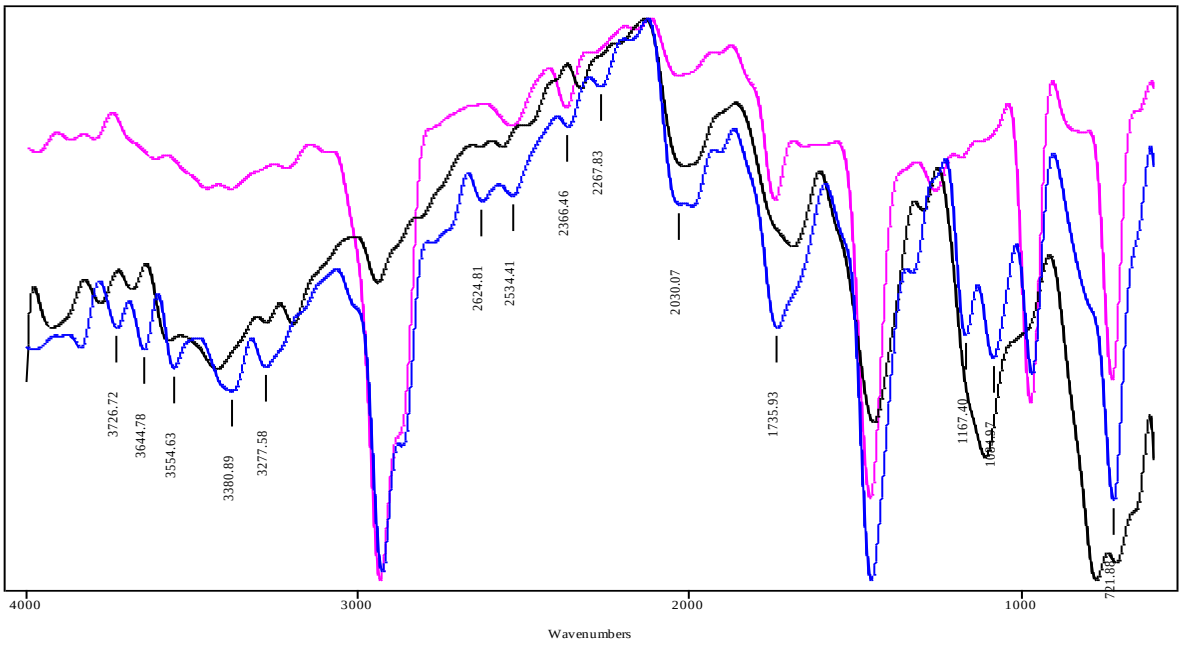

Figure 9: FTIR of Three Analysed PVA Paints

CONCLUSION

Polyvinyl Acetate copolymer was formulated by mixing the polyvinyl acetate with three samples of groundnut oil. The effect of concentration, composition of the blended oil samples were studied, based on, Drying time, Flexibility, Solubility in water. Dry to touch, Density (g/cm^3), and values of pH and Resistance to blistering indicated that locally perbricated paints from Groundnut oil can serve as supplement to paintings. FTIR result showed functional groups of the derived paints showed other functional groups such as; C-O, C=C, C-O, C-H, C-N and C=N at specific wave length and peaks due to presence of compounds such as Hydroxyl, Amines, Carboxylic acids, Alkyhallides, Ketones, Alkanes Aldehydes are present in paints that serves as co-binders in the fabricated paints analyzed.

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