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**Original Research Article**

# Formulation of Emulsion Paint Using Benign HGSO/PVAC Copolymer As A Binder

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**ABSTRACT**

This study focused on developing and characterizing an emulsion paint formulated from a copolymer binder of polyvinyl acetate- hydroxylated guna seed oil (PVAc/HGSO) and compared with paint made from conventional polyvinyl acetate (PVAc) binder. Seed oil from guna was extracted mechanically using cold press method, and the extracted guna oil were successively subjected to epoxidation and hydroxylation reaction processes. The hydroxylated guna seed oil (HGSO) was copolymerised with conventional polyvinyl acetate in different ratio of 10 to 70% of hydroxylated oil, to formulate a novel PVAc/HGSO copolymer binder. The formulated copolymer binder was characterised, and compared with the standard inorder to ascertain the better blend ratio that will be suitable for paint production. The better blend copolymer binder was used in production of an emulsion paint. The physico-chemical parameters on the formulated emulsion paint were compared with paint formulated using only PVAc as a binder and acceptable value in the coating industry. The novel formulated emulsion paint found to be increased in gloss, adhesion and flexibility, which are major setback in paint produced using conventional PVAc only as a binder.

**Keywords:** Cold press, Guna Seed oil, Hydroxylation, Copolymerisation, Polyvinyl acetate (PVAc)

## Introduction

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According to [1, 2], painting and coatings are unique activities that have assisted the human race to contribute meaningfully in earning a better livelihood . Paint not only beautify, but has also helped people to coin a distinguish culture for themselves. It is a true fact that paint has transcended to be an impotant commodity for cultural identity and celebration. Paint has been known to be of great value in building, decorating and spelt symbols in industry. Several studies [1, 3, 4] buttressed that, paint offers an cost-effective protection, conservancy and decoration, including aesthetic and improves functionality to structures. Paint is defined as any liquid, liquefiable, or mastic composition that after application to a substrate in a thin layer, converts to a solid film [5]. It is most commonly used to protect, colour, or provide texture to objects. Abubakar and Gidigbi [6] reiterated that paints are broadly categorized into two major types , such as water based (emulsion) paint and Oil based paints. According to [7] , Oil based paint possess unique qualities such as: good flexibility, low moisture uptake, better glossiness and excellent durability. However, due to the emission of Volatile Organic Compounds (VOCs) from the surface of the substrate, which has been attributed as a contributing factor to greenhouse effect, this has necessitated the reduction in the usage globally [8]. Although, previous studies [9, 10] revealed that water-based paint (Emulsion Paint) was reported to be environmental friendly , since there is no release of harmful substance to the environment , but [2, 5] reported that water-based paint has poor glossiness and high moisture uptake which encourages bacteria activities and overall, affect the durability of the paint. According to [1, 11, 12], the binder is an essential paint's ingredients, as it is responsible for film formation in paint. Polyvinyl acetate (PVAc) is a major binder used in the formulation of emulsion paint. Unfortunately, binder has been responsible for the drawback in emulsion paint, as it is poor water resistance, and very soluble in water. Therefore, there is a need to develop new binder to compensate for inadequacies in emulsion paint. On the other hand, [13] reported that, Citrullus vulgaris (guna) plant is from a species of the Cucumbitaceae or Cucurbit. The Citrullus vulgaris (guna) was found to be abundant in a study area and also has medicinal and nutritional advantages [18]. Chemical assessment revealed the presence of carbon to carbon double bond in their triglyceride backbone which serve as a site for further chemical interaction. Although few seed oil had been used to modulate polyvinyl acetate, but none has really utilized guna seed oil to improve the performance of polyvinyl acetate. Therefore, guna seed oil is used to modify PVAc inorder to improve the performance of emulsion paint.

## Materials and Methodology

### Materials

Guna seed oil, PVAc, Acetic acid, Formic acid, NaOH, HCl, Sodium dihydrogen phosphate, Sulphuric acid, Formic acid, Hydrogen peroxide, Kaolin, Butanol, Petri dishes, Beakers, Conical flasks, Measuring cylinders, three neck flask, hot plate, condenser. All chemicals are of high analytical grade.

## Methodology

## Extraction, epoxidation and hydroxylation of Guna Seed Oil

Guna seed oil was extracted manually, according to the method described by Evwierhoma and Ekop [14] . Epoxidation procedure was carried out on the extracted Guna Seed Oil using the method described by [1, 5]. Hydroxylation procedure was carried out on the epoxidised Guna Seed Oil, using the procedure described by [10, 15].

## Copolymerisation of PVAc with HGSO

The PVAc/HGSO copolymer was prepared by carried out various blends (0-70%) of the HGSO in PVAc according to the method described by [1, 16, 17] .

## The physical properties of the blended resin films

### Determination of Moisture Uptake, Viscosity and Gel time

The moisture uptake for the new copolymer binder was carried out gravimetrically using the procedure described by [18]. Average value of triplicate determinations of each sample was recorded.

### Determination of Viscosity, Gel Time, water solubility and elongation at break

Viscosity and gel time was carried out according to method described by [6]. Solubility of the resins in water was determined by mixing 1ml of the resin with 5ml of distilled water at room temperature (30°C). while elongation at break was determined according to the method described by

### Density, Turbidity, Melting Point and Refractive Index

Density was determined using density bottle of standard volume as described by Gidigbi *et al* [1] , while turbidity was determined using Supertek digital turbidity meter (Model 033G) , and The melting point was determined by using Galenkamp melting point apparatus (Model MFB600-010F). The refractive index of the sample was determined with Abbe refractometer. The above properties were determined according to standard methods.

## Paint Formulation

The emulsion paint was formulated according to the method described by [2, 6, 10].

## Results and Discussion

### Results of The Physical Properties of PVAC/HGSO Copolymer Binder

Table 1 below described the physico-chemical properties of a novel PVAc/HGSO copolymer binder, and compared with the PVAc binder and acceptable level in the coating industry.

**Table 1:** Comparison of physical properties of PVAc and PVAc /HGSO binder

| Parameters | PVAc | HGSO/PVAc | Acceptable Level in the coating industry Osemeahon *et al.*, [18]. |
|---|---|---|---|
| Density (g/cm3) | 1.211 | 1.091 | 1.07 (min.) |
| Refractive index | 1.400 | 1.419 | 1.4000 (min.) |
| Moisture uptake (%) | 0.409 | 0.221 | 3.10 (max.) |
| Viscosity (Mpa.s) | 33.87 | 23.52 | 3.11- 38.00 |
| Melting point ($^{o}$C) | 179 | 162 | 200(max.) |
| Elongation at break | 312 | 391 | 125(min) |
| Turbidity (NTU) | 1639 | 1621 | - |
| Gel time (Min) | 152 | 250 | - |
| Solubility | Soluble | Soluble | - |

### Comparison of the value of some physical properties of novel PVAc/HGSO copolymer binder and other copolymer binders in the literature.

Table 2 compared the value of some of physico-chemical properties of PVAc/HGSO copolymer binder with other copolymer binders in the literature.

Table 2: Comparison of the physico-chemical properties of PVAc/HGSO copolymer binder with other copolymer binders in literature

## Some physical properties of paints formulated from PVAc and PVAc/HGSO Binders

Table 3 compared the result of physical properties of an emulsion paint formulated using new PVAc/HGSO copolymer binder with the paint formulated with polyvinyl acetate and the Standard Organisation of Nigeria

| Type of binder | Physical property | | | | | | | Literature |
|---|---|---|---|---|---|---|---|---|
| | Viscosity (mpa. s) | Refractive Index | Density (g/cm$^3$) | Melting point (°C) | Moisture uptake (%) | Elongation at break (%) | Formaldehyde emission (ppm) | |
| PVAc/HGSO | 23.52 | 1.400 | 1.091 | 162 | 0.221 | 391 | ND | This study |
| UF/PE | 32.60 | 1.432 | 1.3362 | 130 | 0.0080 | 250.0 | 0.0142 | Osemeahon and Archibong [19] |
| Palmoil/Alkyd | 499 | ND | 0.929 | ND | ND | ND | ND | Mohialdeen [20] |
| TMU/PS | 19.70 | 1.425 | 1.099 | 262 | 1.01 | 425 | ND | Osemeahon and Dimas [5] |
| HASO/PVAc | 24.11 | 1.428 | 1.098 | 169 | 0.137 | 418 | ND | Gidigbi *et al.*, [1] |

| Parameter | PVAc | PVAc/HGSO paint | SON Standard [21] |
|---|---|---|---|
| pH | 7.23 | 8.09 | 7-8.5 |
| Viscosity (poise) | 14.9 | 12.11 | 6-15 |
| Flexibility | Pass | Pass | Pass |
| Opacity | Pass | Pass | Pass |

| | | | |
|---|---|---|---|
| Adhesion | Pass | Pass | Pass |
| Hardness test | Pass | Pass | Pass |
| Tackiness | Pass | Pass | Pass |
| Resistance to blistering | Fail | Pass | Pass |
| Drying time (min) | | | |
| Touch | 29 | 34 | 20 |
| Hard | 41 | 63 | 120 |

**Table 3.**1.4: Chemical Resistance of PVAc and PVAc/HGSO Paint Films

| | Media | | |
|---|---|---|---|
| Samples | 0.1M NaCl | 0.1 M HCl | 0.1 M NaOH |
| PVA | A | B | A |
| PVAc/HGSO | A | A | A |

Key word, A= No effect, B= Cracking, C= Blistering

## Discussion

### Discussion on the physico-chemical properties of novel PVAc/HGSO copolymer binder

Table 1 revealed the value for the physico-chemical properties of the novel PVAc/HGSO copolymer binder. All the values are within the acceptable range for an emulsion paint binder. Therefore, the new copolymer binder can be subsequently used as a binder in an emulsion paint. On comparison with the PVAc binder, the novel PVAc/HGSO copolymer binder showed improved properties in viscosity, which means better application of paint, high refractive index which means an improve in paint sheeness and low moisture uptake which implies durability [22]. This result is also in consonance with Ibrahim et al [12] who investigated the feasibility of using blend of natural rubber with Polyvinyl acetate as a copolymer binder for an emulsion paint. Muhamad and Yelwa [17] agreed that modifying polyvinyl acetate as an emulsion paint binder, has an advantageous benefit to the coating industry. This is further buttressed by Gidigbi et al [1] that modified poly vinyl acetate copolymer binder has improved properties such as better flow ability, enhanced sheeness and cost effective. Hydroxylated Guna Seed Oil (HGSO) demonstrates a good compatibility with poly vinyl acetate (PVAc), thereby creating a copolymer binder with better adhesion and excellent cross-linked parameter.

## Discussion on the comparison of physico-chemical properties of novel PVAc/HGSO copolymer binder and compared with other copolymer binder from the literature.

Table 2 showed the comparison of some properties of the novel the novel PVAc/HGSO copolymer binder compared with other copolymer binders from the literature. The novel PVAc/HGSO copolymer binder does not emit formaldehyde, as compared to copolymer of Urea formaldehyde and Polyethylene (UF/PE) binder as reported by Osemeahon and Archibong [19], and urea formaldehyde with polyvinyl acetate (UF/PVAc) as reported by Iqbal et al [23]. The novel PVAc/HGSO copolymer binder also has better viscosity compared to monomethylol urea binder reported by Archibong et al [24]; and improved density reported for blend of Polyvinyl acetate and Hydroxylated Neems Seed Oil (HNSO/PVA) copolymer binder by Muhammed and Yelwa [17]. This showed that paint made from this novel copolymer binder will be flexible on application, with good adhesive property on substrate.

## Discussion on Physical parameters of paints formulated from PVAc/HGSO copolymer binder

Table 3 revealed the results of physical properties of paint made from blend novel Polyvinyl acetate with hydroxylated guna seed oil (PVAc/HGSO) copolymer binder and the paint made from commercial PVAc. The paint made from the new PVAc/HGSO copolymer binder has high pH value of 8.09 compared with 7.23 from commercial paint. This was as a result of the presence of hydroxyl group in the novel PVAc/HGSO binder. The pH value is usually used to create buffer solution in paint inorder to minimize the growth of microbes [25]. the pH of this study is within the range of Standard Organisation of Nigeria (SON), and also in consonance with that of paint developed from Hydroxylated Avocado Seed Oil/ Polyvinyl acetate (HASO/PVAc) copolymer binder reported by Gidigbi et al [1]. Also, the paint from novel PVAc/HGSO copolymer binder has lower viscosity of 12.11 poise compared to 14.9 poise from commercial paint. This indicate flexibility, smoothness and better consistency [11]. Both are within the acceptable range of Standard Organisation of Nigeria. Although, the drying to touch time of the paint made from novel PVAc/HGSO copolymer binder exceed SON stipulation, due to the presence of lipophilic nature of hydroxylated guna seed oil, but fall within the SON range for drying hard. Also, slow drying prevents cracking during the cross-linking process of paint. The paint developed from novel HASO/PVAc copolymer binder passed tackiness assessment. This indicates the good adhensibility of paint to substrate [26]. The paint produced from novel PVAc/HGSO passed the test of blistering, while commercial paint failed. This may be connected to the presence of hydrophobic component in the copolymer binder formation, as the hydroxylated seed oil presence in the novel copolymer binder is semi-hydrophobic, thereby addressing one of the major shortcoming of conventional paint, which is poor water resistance [27].

## Discussion on Chemical Resistance property of the paint

Table 4 revealed the chemical property of the paint formulated from both novel PVAc/HGSO and PVAc. According to [6], chemical resistant is one of the major determinant of usability and durability of paint. It is a measured of ability of paint to resist chemical interaction that may lead to discolorisation. This is known as wash-ability resistance. According to Ibrahim et al [12], the higher the washability resistance, the better the quality of the emulsion paint. The paint made from the novel PVAc/HGSO and PVAc were exposed to salt, acid and alkaline solutions. While commercial paint produced from PVAc passed salt and alkaline solution, but was fairly affected by acidic solution. Meanwhile, the chemical integrity of paint made from the novel PVAc/HGSO copolymer binder were not compromise when exposed to salt, acidic and alkaline medium. This may be due to excellent cross-linking network which inhibit interaction with other external factors , thereby causing it to last longer [28, 29].

## CONCLUSION

The copolymer PVAc/HGSO binder was successfully synthesized by blending polyvinyl acetate with hydroxylated guna seed oil. The best ratio of blend chosen for the production of novel PVAc/HGSO was based on the alignment of important parameters with the acceptable value in the coating industry. The best ratio for the novel copolymer comprises 20% of HGSO and 80% of PVAc. This novel copolymer binder showed better viscosity, good water resistance and excellent refractive index compared to common PVAc binder. The emulsion paint formulated using PVAc/HGSO binder indicates a good consistency, smoothness and uniformity. It also addressed a major shortcoming in commercial emulsion paint by resisting blistering and demonstrate excellent chemical integrity by resisting discolorisation in salt, acidic and alkaline medium.

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