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Production of Water and Oil Based Paints Using Hydrosol Obtained from Locally Sourced Materials

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Abstract— *Water based paint (emulsion, screeding, matt paint) and oil paint (gloss paint) were produced using hydrosol formulated locally by adopting steam method. The raw materials were hibiscus flowers, mint leaves, rosemary and lemon grass. Soxhlet extractor was used to hydrosol from the crushed leaves using normal-hexane as solvent. Distillation process was carried out to separate the hydrosol from the solvent in the hydrosol-solvent mixture, obtained from the extraction process. The hydrosol was characterized to determine the physiochemical properties and hence its suitability for paint production. The results showed the physicochemical parameters of the produced hydrosol were within the standard values, of Refractive index = 1.3698, pH = 6.5533, conductivity = 0.5167us/cm, TDS = 78.1667mg/l, density = 0.5183g/cc, specific gravity = 0.5183, viscosity = 8.1083cst, boiling point = 74.70C. The produced hydrosol was used in the production of emulsion, screeding, matt and gloss paints which were characterized and they gave the following physicochemical results of pH = 6.90, 6.94,7.39& 6.62. Specific gravity = 23.75, 23.75, 23.75 & 23.75. density = 1.4078g/cc, 1.2396g/cc, 1.136g/cc, & 1.1164g/cc. viscosity = 9.8cst, 10.5cst, 10.8cst and 8.47cst. drying time= 6hrs, 6hrs, 4hrs & 6hrs. Temperature = 280C, 280C, 280C& 280C. Wet = 2.55, 2, 4 & 3 respectively. These results showed reasonable agreement when compared with standard.*

Keywords— *Hydrosol, Water and Oil Based Paint, Physicochemical Parameters.*

I. INTRODUCTION

Nigeria's paint industry has witnessed a remarkable growth over the last five years with the number of player increasing rapidly to more than fifty consisting of several private manufacturing companies. Individual entrepreneurs have also keyed into the paint production business through the paint production, marketing and sales for income generation. These entrepreneurs simply buy the components of paint and with their limited knowledge in paint production are able to turn their homes or offices into paint factory. However, industrial survey shows that Nigeria paint industry is dominated by the importation of practically all the important component of paint production. The demand effect is a high rise in the cost of raw materials for paint production – thus making them unaffordable for many type of paint production. Consequently, there is an urgent need to explore the use of locally sourced raw materials for paint production. Further studies are the design of reactor types for paint production. Idris *et al.* (2017) did an extensive Laboratory studies on small scale production of three different grades of emulsion paints. The quest to revive the nation's economy toward local production of goods and services and gaining employment of our teaming youths revolves through encouragement and development of small scale production. Emulsion paints were formulated using different local raw material as pigments and at different pigment volume concentration of 32%, 19% and 10%. Polyvinyl acetate was used as binder, with dispersant and solvent. The effects studied and the higher concentration of pigment produced better results, as more compatibility with the binder, and deeper colour for the paints formulated were obtained. The physico-chemical properties such as viscosity, density, drying time, opacity, and PH for the formulated. Kazaure *et al.* (2014), characterized emulsion paints formulated using reactive-dyed starch as a by reactive dyed potato and cassava starch as pigment at different pigment mass concentration as 40%, 30%, 20% and 10%. The polyvinyl alcohol as binder, with a dispersant and a solvent. The effect of varying concentrations of pigments and production of oil and water paints using locally sourced materials were investigated in this work with the aim of utilization of local content in reducing the cost of importation of raw material and consequently, the cost of production of paint in the country.

II. MATERIALS AND METHODS

2.1 Materials

The materials used for the production of emulsion and oil paints, reagents and apparatus are listed in Table 1.

TABLE 1: Reagents and Chemicals for the Different Paint and Hydrosol Production

S/N	Paint	Hydrosol
i.	Titanium oxide	Mint leaf
ii.	Calcium carbonate	Lemon grass
iii.	Acrylic	Rose mary
iv.	Ammonia	Hibiscus flower
v.	Hydrosol	Hexane
vi.	Texanol	
vii.	Aluminum silicate	
viii.	Bermacol	
ix.	Biocide	
x.	Anti-skin	
xi.	Anti-fungi	
xii.	Perfume	
xiii.	Colour (pigments)	
xiv.	Alkyd-Resin	
xv.	Lead-dryer	
xvi.	Kerosene	
xvii.	H_20	
xviii.	D.O.P	
xix.	Famalyn	
xx.	Mixer dryer	

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2.1.1 Apparatus for paint and hydrosol production:

i. 250ml beaker
ii. 500ml round bottomed flask
iii. Measuring cylinder (100cm^3)
iv. Retort stand
v. Test tubes
vi. Soxhlex extractor
vii. Round bottom flask
viii. Condenser
ix. Host/pipes
x. Heating mantle
xi. Distilled water 100 cm^3
xii. Eye protection
xiii. Thermometer
xiv. Batch reactor
xv. Nose mask
xvi. Handglove
xvii. container with lid

2.2 Methods

The methods adopted for the research are experimental procedures carried out in the Chemical/Petrochemical Engineering Laboratory, Rivers State University, Nkpolu Oroworukwo Port Harcourt for the production of different types of paints.

2.2.1 Emulsion Paint Production

The emulsion and oil paint production were carried out experimentally through the following procedures stated below:

2.2.1.1 Sample Collection

Hydrosol was extracted from local raw materials gotten from Agricultural farm Rivers State University, Nkpolu, Port Harcourt and fruit garden located at Kaduna street D/ line Port Harcourt.

2.2.1.2 Experimental Set-Up

The experiment was carried out using solid liquid extraction process (Leaching process). This method was used to extract hydrosol from plants materials. A Batch reactor was used for the paint production in Chemical/Petrochemical Engineering Laboratory Rivers State University.

2.2.1.3 Production of Hydrosol

Water distillation and steam distillation is the most favored method of producing hydrosol oil from plant materials. Fresh samples of rose flower, mint leaf, lemon grass and hibiscus flower were collected and sliced into pieces for use. Hexane was used for the extraction process; all of the other chemicals used were of analytical grade. The feed (lemon grass, rose flower and rosemary flowers, and mint leaves) was prepared, and 60% of hexane by volume was measured and put into a conical flask. The feed of varying weight (40g, 80g, 120g, 160g, 200g and 240g) was fed into the thimble and into the feed chamber where steam distillation process was carried out at varying temperatures ranging from (50^0C, 70^0C, 90^0C, 110^0C, 130^0C and 150^0C) at different time intervals of (30mins, 40mins, 50mins, 60mins, 70mins and 80mins) respectively. The product from the steam distillation column was collected and put into the bottle and weighed. Sample was collected into a test tube and put into cold water in the beaker for gradual cooling. The distillate and residue of the resulting product was analyzed to determine the refractive index, flash point and other physicochemical parameters and values recorded.

2.2.2 Production of Matt Paint (20L)

5L of water was added in a paint mixer with 2L of Toluene. 2kg of Titan was also added and 7kg of $CaCO_3$ was also added and the mixture was stirred continuously, and the 5kg of acrylic and the mixture was stirred continuously. 100mg of Bermacol with 100g of deformer was also added. 200mg of hydrosol produced was also added. 100mg of Genapour was added with 100mg of Biocide, 100mg of anti-skin, 50mg of NH_3 and 100mg of Texanol were all added and mixed thoroughly and then stirred for 30 minutes time and product ready for package and storage.

2.2.3 Production of Screeding Paint (20L)

10L of water was added in the paint mixer and 18kg of calcium carbonate was dissolved in the water, 2kg of polyvinvyle acetate was added with 3kg acrylate. 100g of Bermacol and one Liter of kerosene was added together with 100mg of Biocide, 200mg of hydrosol, 100mg of anti-skin and 50mg of ammonia. The mixture was stirred continuously 30mins before the product was ready for packaging and storage for usage.

2.2.4 Production of Emulsion Paint (20L)

10L of water was added in the mixer with 250g of Titan. 15kg of calcium carbonate was weighed and transferred in the mixer and was allowed to stirred continuously for 10mins. Then 100g of yellow oxide (colour) was added for colouration. 100g of Bermacol was also added with 2kg of Acrylate and 100mg of deformer was also added with 200g of hydrosol for polishing of the paint and stirred continuously. 100mg of Gernapour and 100mg of Texanol were also added together with 50mg of ammonia and also 100mg of anti-skin and allowed for 30mins with continuous stirring. The resulting product was packaged and stored.

2.2.5 Production of Four (4) Liters Oil Paint

Kerosene 1.5l was mixed with 1.5kg of alkyl resin into a mixer and stirred for proper mixing. Then 300g of Titanium Oxide and 100g blue oxide for coloration of the paint was added and mixed in the mixer.100mg of lead dryer and 50mg of Anti-skin with 200mg of hydrosol were all added and allowed for 30mins with continuous stirring. The product was collected and stored.

2.3 Physicochemical Analysis for the produced Hydrosol

2.3.1 Determination of Refractive index of Hydrosol:

Using the refractometer with precision 1.30 to 1.63, thermostat and circulating pump capable of maintaining the indicated temperature constant within 0.04^{o}F. The prism face was cleaned thoroughly and the instrument calibrated to standard level, then the thermostat was adjusted to match 0.4F. Small amount of the hydrosol was dropped on the prism face. Light was turned on and through the eyepiece lens; the refractive index was obtained and recorded.

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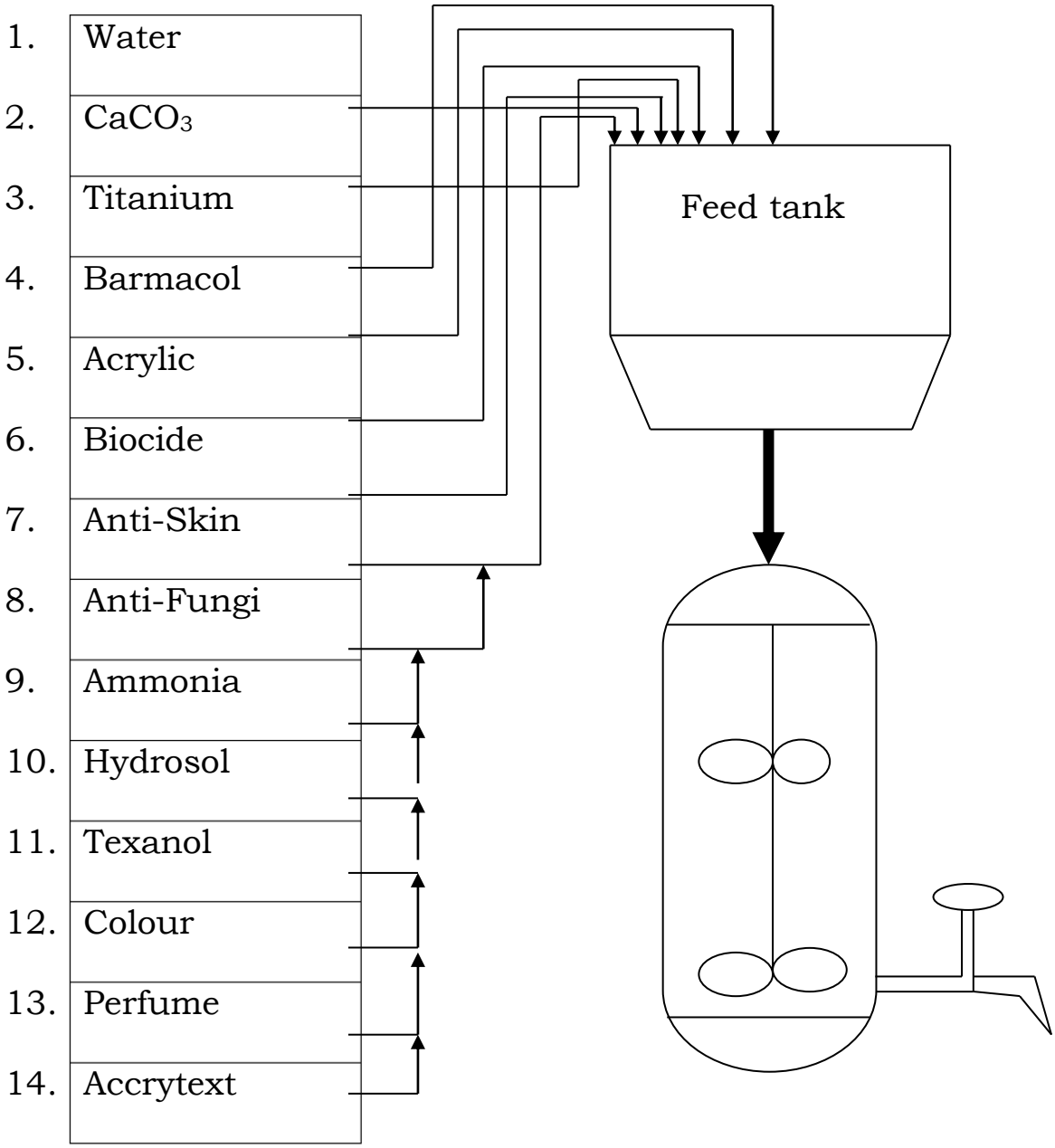

Figure 1: Flow Chart for the Mixing of Paint

2.3.2 Determination of TDS of Hydrosol (Total Dissolved Solid)

For this, an apparatus called the Hatch TDS meter and a beaker were used. The TDS Meter was put on and the probe was rinsed. 100mls of the Hydrosol was measured into a beaker and the probe was immersed into the sample, the readings displayed was recorded by the TDS meter in mg/l

2.3.3 Determination of Specific gravity and density of Hydrosol (ASTMD 591)

The specific gravity was determined using Pycnometer method, the empty pycnometer was weighed and empty weight recorded. The pycnometer was filled to the brim with the Hydrosol sample and the weight of both the sample and the pycnometer was recorded. The mass of the sample was subtracted from the empty weight which was divided by the volume (50ml) of the bottle.

2.3.4 Determination of Kinematic Viscosity of Hydrosol (ASTMD 2196)

The tube reverse flow viscometer was used for measuring kinematic viscosity, 25ml of the hydrosol sample was measured into the viscometer up to the mark, the temperature of the hydrosol sample was raised to 50^{o}C, the sample in the viscometer was pumped up to the upper unit of the viscometer, the paint sample was released to flow down to the lower unit, time of flow was taken using stop clock.

2.3.5 Determination of pH of the Hydrosol (ASTMD 1208)

100ml of the Hydrosol sample was measured into a measuring cylinder; microcomputer pH meter probe was used

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in determining the pH value of the hydrosol and was standardized using buffer solution, the probe was inserted into the hydrosol sample in the measuring cylinder, the pH Meter switched on, the pH value displayed on the meter was recorded.

2.4 Physicochemical Analysis for the produced paint

The samples of the different types of paints produced were used for the analysis of the physical and chemical properties.

2.4.1 Determination of Temperature Stability of Paint (ASPH 4500T)

50ml of paint was measured and poured into air tight container. An automated temperature probe sensor was used to record the temperature stability for 24 hours.

2.4.2 Determination of Kinematic Viscosity of paint (ASTMD 2196)

The tube reverse flow viscometer was used for measuring kinematic viscosity, 25ml paint sample was measured into the viscometer up to the mark, the temperature of the paint sample was raised to 50^{o}C, the sample in the viscometer was pumped up to the upper unit of the viscometer, the paint sample was released to flow down to the lower unit, time of flow was taken using stop clock.

2.4.3 Determination to Resistance to Wet Abrasion Paint (ASTMD 1364)

Paint sample was coated on a wall with a roller and brush and allowed to dry for 5-hours. Then, water of a given flow rate was sprayed through a pumping channel directing to the paint coated wall for 30 minutes. This test was carried out after 5 hours coating to confirm resistance to the wet abrasion of the paint.

2.4.4 Determination of pH Paint (ASTMD 1208)

100ml of the paint sample was measured into a measuring cylinder; microcomputer pH meter probe was used in determining the pH value of the paint was standardized using buffer solution. The probe was inserted into the paint sample in the measuring cylinder, the pH value displayed on the meter was recorded.

2.4.5 Determination of Specific gravity paint (ASTMD 591)

The specific gravity was determined using Pygnometer method, the empty pygnometer was weighed and empty weight recorded. The pygnometer was filled to the brim with the paint sample and the weight of both the sample and the pygnometer was recorded. The mass of the sample was subtracted from the empty weight which was divided by the volume (50ml) of the bottle.

$$\rho = \frac{M}{V} \quad (1)$$

Where: M Mass of pygnometer (final - initial) weight; V is sample volume that was (50ml).

III. Results and Discussion

Table 1 show that the produced Hydrosol is within acceptable limits when compared with standard values. The produced Hydrosol was used for the production of various types of paints such as Emulsion paint; screeding paint; Matt paint and Gloss paint, and the paints produced were analyzed for various essential parameters.

TABLE 1: Comparison of Physico-Chemical Parameter of the Produced Hydrosol with Standard Values

Analyzed Variables A.Vs	40g	80g	120g	160g	200g	240g	Average analyses(∇n)	Standard values of A.Vs	Industrial standard
Ref. Index	1.3601	1.3682	1.3882	1.3951	1.3066	1.4003	1.3698	1.3 – 1.4	1.41433
pH	6.12	6.20	6.37	6.95	6.85	6.8	6.5533	>5	6.88
Conductivity ($\mu s/cm$)	0.74	0.70	0.72	0.89	-	-	0.5167	-	1.08
TDS (mg/l)	73.5	73.6	84.2	76.7	79.4	81.6	78.1667	<100	92.00
Density (g/cc)	0.74	0.72	0.73	0.92	-	-	0.5183	0.7 – 0.8	0.75
Spec. grav	0.74	0.72	0.73	0.92	-	-	0.5183	0.7 – 0.8	0.75
Viscosity (cst)	7.51	7.71	7.98	7.8	8.22	9.43	8.1083	< 10	8.30
Boiling point (^{0}c)	65.6	58.5	71.4	83.0	85.0	84.7	74.7	70 – 80	78.00

TABLE 2: Results obtained from Characterization of the Essential Parameters of the Different types of Paint

Type of Paint	PH	Sg	Density	Viscosity	Drying	Temp.	Wet
Emulsion	6.90	23.75	1.4078	9.8	6	28	2.55
Screeding	6.94	23.75	1.2396	10.5	6	28	2
Matt	7.39	23.75	1.136	10.8	4	28	4
Gloss	6.62	23.75	1.1164	8.47	6	28	3

Table 2 indicates the results obtained from the characterization of the essential parameters of different types of paint such as pH, Sg (specific gravity), Density, viscosity, Drying Time, Temperature, wet/withstanding of the different types of paint (Emulsion, Screeding, Matt and Gloss). From Table 2, the pH value, matt has high pH of 7.39, followed by screeding; 6.94, Emulsion; 6.9 and lowest for gloss; 6.62. Their specific gravity of the paints is same with value of 23.75.

Table 3 shows the comparison of emulsion paints with standard values for acceptability and reliability. The results showed that the produced paints through hydrosol have suitable properties good enough to substitute standard materials for the production of paints.

TABLE 3: Comparison of Results from Characterization of Water Based Paints with Standards Values

S/N	Parameter	Result	Standard
1	pH	6.94	>5
2	Density (g/cc)	1.2396	1.0-2.0
3	Opacity	Good/ Acceptable	Good/Acceptable
4	Viscosity (cst)	10.5	
5	Drying time (hrs)	6hrs	7hrs
6	Peeling/Adhering	Acceptable	Acceptable
7	Wet/withstand	3mins	3-10mins

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Table 4 shows the parameters of oil paints characterized and analyzed after production, and the results obtained were compared to standard values for acceptability and reliability. The results showed that the paint produced using hydrosol have suitable properties good enough to substitute standard hydrosol for the production of paint.

TABLE 4: Comparison of Results from Characterization of Oil-Based Paints with Standard Values

S/N	Parameter	Result	Standard
1	pH	6.62	>5
2	Density	1.116	1.0-2.0
3	Viscosity	8.47	-
4	Opacity	Good/Acceptable	Good/Acceptable
5	Skinning	Nil	Nil
6	Adhesion	Acceptable	Acceptable
7	Appearance	Acceptable	Acceptable
8	Drying time	6hrs	7hrs

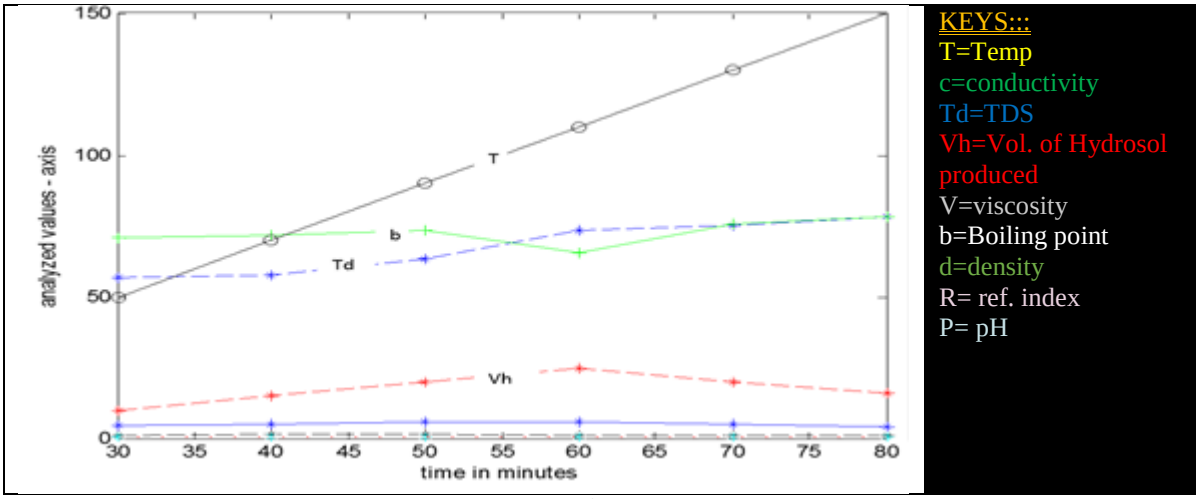

Figure 2: Composite Graph of Time against Analyzed Values

Figure 2 is the composite graph for the entire analyzed variables plotted against reaction time (t) ranging from 30minutes to 80minutes under control heating and with N-hexane(C_6H_{12}) as the intermediate compound. From the plot, it can be seen that as the reaction time for Hydrosol production using N-hexane as the intermediate compound for solid-liquid extraction, increases, from 30minutes to 80minutes, there is a normalized progression with very slight change in values for various parameters.

IV. Conclusion

The production of the different types of paints (Mat, screeding, Emulsion and Gloss) was carried out in this research work from hydrosol produced from four different plants namely mint leaf, Rosemary and hibiscus flowers and lemon grass. The essence of using locally sourced raw material was to enable variety of different and available raw materials at cheaper cost for the paint industry. The research firstly considered the availability of the ingredients (raw materials) for the formulation of the hydrosols and then the sampling of the produced hydrosol to tests the parameters. A 40g, B 80g, C 120g, D 160g, E 200g and F 240g were the different weights of hydrosol sampled and analyzed to determine the values and results of the physicochemical properties suitable for use in the manufacture of paint. It was noticed that temperature and specific gravity of the hydrosols were at constant value throughout but other physicochemical properties parameters vary and their values increase at higher weight of the hydrosol. The four different types of paints produced using hydrosol were analyzed to determine the values of the various physicochemical properties. The results of the analysis revealed that the paints produced were suitable and acceptable as the values of the physicochemical properties compared to the standard values are within the acceptable range.

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