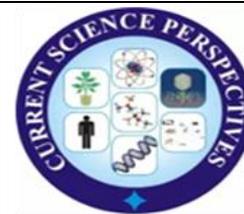




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Characterization of latex from trees in the Bobiri forest of Ghana

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ABSTRACT

In this study, ten latex samples collected from different trees in the Bobiri forest in the Ashanti region of Ghana, were characterized based on FT-IR, viscosity, protein content, ash content, crosslink density, surface tension and rubber content. The results were compared to that of *Hevea brasiliensis*, which was used as reference. FT-IR analyses showed peaks at 1637.06 and 2963.61 cm^{-1} (C-H bond) and 1450.06 and 1470.00 cm^{-1} (C=C bond). These peaks are common with isoprene units (C_5H_8). Of all the samples, *Hevea brasiliensis* had the highest rubber contents of 56.18%, and lowest total solids and crosslink density of 14.98 and 0.08 respectively. *Pycnanthus angolensis* was the most viscous. With respect to total solids and coagulum content, *Landolphia hirsuta* had the highest percentages of 88.4 and 13% respectively. Based on their properties, these latexes could be used as alternatives to *Hevea brasiliensis*.

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Capsule Summary: The characteristics of latex from trees such as rubber content, coagulum content and surface tension indicate that *Funtumia elastica* can replace *Hevea brasiliensis* as the natural rubber source.

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INTRODUCTION

Bobiri Forest Reserve and Butterfly Sanctuary is one of the ecotourism centres in Ghana. It is found at Kubease, a village in the Ashanti region of Ghana. It is a research center for the Forestry Research Institute of Ghana with a collection of trees. Among these, are varieties of latex trees (Wagner et al., 2008).

Latex is a stable milky fluid of polymeric substances dispersed in an aqueous medium. It is made up of essentially two phases; dispersed and continuous. The dispersed phase is a discontinuous phase that consists of rubber molecules and dispersion medium whereas the aqueous continuous phase is made of serum (Lewinsohn, 1991). There are two

types of latexes; natural and synthetic latex from plant and petroleum products respectively. The composition of natural latex includes alkaloids, terpenoid compounds, polymeric substances such as resins and gums, starch, oils, carotenoids, and proteins (Pallardy, 1991). The variations of the components are due to factors such as clone, how fertilizer is applied to the soil, season, soil conditions and the frequency at which the latex is tapped. Rubber formed from latex is elastic and about five hundred rubber plant species can produce latex (Lewinsohn, 1991). The major source of latex is *Hevea brasiliensis* (Alenius, 2006), due to the fact that it produces copious yield of rubber with outstanding physical properties, which is being utilized in the production of balloons, hospital gloves and vehicle tyres (Asawatreratanakul et al., 2003). The particle sizes of

polymer molecules in latex are different ranging from a diameter of 0.01 to 5 μm but the majority falls within 0.1-2 μm (Pendel et al., 1991). The major chemical composition of latex is cis-polyisoprene. Natural rubber is a polymer composed of many isoprene units with chemical formula C_5H_8 , each containing one double bond in the trans and cis configuration and linked at C_1 and C_4 . Gutta-percha and natural rubber are both natural polymers of isoprene but differ from each other in the stereo-structure. Whereas gutta-percha consists of poly (trans-1,4-isoprene) and is synthesized only by a few plants, mainly occurring in the tropical areas, natural rubber consists poly (cis-1,4-isoprene) and synthesized by more than 2,500 plants species such as *Mimusops balata*, *Eucommia ulmoide* and also some fungi (Bamba et al., 2002). Trans-polyisoprene is unique in properties as compared to cis-polyisoprene. It is very rigid, excellent for insulation, has low coefficient of thermal expansion, contraction and it is resistant to acid and alkali. Such properties have been exploited in the production of insulated cables, moulds, sport goods, medical or scientific instruments (Jiang et al., 2008). Presently, trans-polyisoprene is manufactured synthetically and no plant based source has been tapped for commercial use. Almost all commercially produced natural rubber is obtained from *Hevea brasiliensis*, a native plant of Brazil (Berthelot et al., 2014). Russian dandelion is being considered as an alternative source of natural rubber (van Beilen and Poirier, 2007). Natural rubber produced globally for industrial consumption continues to increase. About 24.3 million tons was produced in 2010 representing 11.9 % as compared to the production of 21.7 million tons in 2009 (Shah et al., 2013). To satisfy this growing demand for industrial applications, there is the need to find alternative sources of natural latexes.

The objective of this research was to characterize latexes from different rubber producing plants from Bobiri forest of Ghana in order to bring into light alternatives to *Hevea brasiliensis*.

MATERIAL AND METHODS

Reagents

Acetic acid, toluene, boric acid, sulphuric acid, ammoniacal alcohol, Dragendolff's reagent, chloroform, sodium thiosulphate ($\text{Na}_2\text{S}_2\text{O}_3$), methyl red 0.2 g / 100 ml ethanol, methylene blue 0.2 g /100 ml ethanol, potassium sulphate

(K_2SO_4), tetrahydrofuran (THF), hydrochloric acid, copper (II) tetraoxosulphate (VI) (CuSO_4), sodium hydroxide (NaOH), tetraoxoborate (V) acid (H_3BO_4) and trioxonitrate (V) acid (HNO_3). All reagents were of analytical grade.

Sampling procedure

Empty plastic bottles were washed with soap and rinsed with tap water, 10 % nitric acid and distilled water and allowed to dry. It was then cut diagonally into two parts with a stainless steel knife. Several cuts were made at the bark of selected latex trees, which were identified under the supervision of a forestry officer at the Bobiri Forest Reserve at Kubease in the Ashanti region of Ghana. The latex was tapped using part of a cut plastic bottle. The latex collected was poured into 1L sterilized plastic bottles fitted with screw tops and put into an ice-chest at the collection sites. In all, ten different latex species were sampled from the Bobiri forest. *Trilepisium madagascariensis* (TM), *Alstonia boonei* (AB), *Antiaris toxicaria* (AT), *Funtumia elastica* (FE), *Pycnanthus angolensis* (PA), *Ficus vogiliana* (FV), *Ficus mucoso* (FM), *Landolphia hirsuta* (LH), *Parquetina eliptica* (PE) and *Hollarhena floribunda* (HF). *Hevea brasiliensis* (HB) was sampled using the same procedure at the Ghana Rubber Estate Limited in the Western Region of Ghana.

FT-IR spectroscopy

Fourier Transform Infrared (FT-IR) analyses of the samples were done at KNUST Central Laboratory. Typically, a drop of the latex was put on the sample holder of Alpha Bruker spectroscopy and then corked for the spectrum to be taken. Scanning was performed from 400 to 4000 cm^{-1} .

Total solids

A cleaned crucible was heated in an oven at 170 $^\circ\text{C}$ for 15 minutes. It was then cooled in a desiccator and weighed. About 1 ml of the latex sample was put in the crucible and reweighed. The crucible containing the sample was put in the oven at 170 $^\circ\text{C}$ for 15 minutes. The crucible with its content was then cooled in a desiccator and reweighed. The total solids (TS) were then calculated from equation 1 below.

$$TS = \left[\frac{(\text{Crucible} + \text{residue Wt}) - \text{Crucible Wt}}{\text{weight of sample}} \right] \times 100 \quad (1)$$

pH

A pH indicator strip was dipped into the latex samples. The color of the strip was then compared to the pH color scale to determine the pH of the latex.

Coagulum content

A cleaned nylon (25micron mesh) was put in an oven for 15 minutes and then stored in the desiccator before the weight was taken (A). The nylon fiber was placed on a Buchner funnel and set on a 200 ml flask. A quantity of 5 g of the sample was weighed into a 1L beaker and 500 ml of distilled water added, stirred and filtered over the nylon filter slowly. The residue was dried at 70 $^\circ\text{C}$ in an oven for 15 minutes,

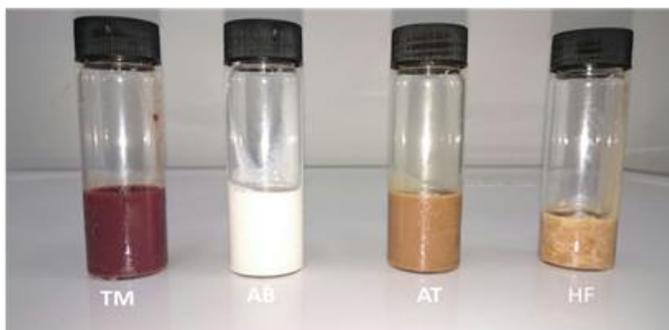


Fig. 1: Different colors of latexes sampled

cooled in a desiccator and the weight recorded (B). It was done in triplicate and the mean recorded.

$$\text{Coagulum content (\%)} = \frac{A-B}{5} \times 100\% \quad (2)$$

Where, A = weight of cleaned nylon filter and B = weight of nylon filter + residue

Surface tension

Using the Kruss tensiometer, approximately 25 cm³ of the latex at room temperature was poured into the tensiometer pan with diameter of about 65 mm and height of about 20 mm. It was ensured that the surface of the latex was freed of air bubbles. The tensiometer ring was cleaned with distilled water and ensured that no oil film traces remained. Extreme care was taken to avoid distortion as the tensiometer ring was handled. The pan containing the latex was placed beneath the ring on the adjustable platform of the instrument. With the instrument adjusted so that the ring system was in its zero position when the ring is stable. The platform was raised until the latex made contact with the ring. The ring was submerged beneath the surface of the latex and slowly lowered the platform-adjusting screw; the torsion of the wire was increased simultaneously, proportioning these two adjustments so that the torsion arm remained exactly in its zero position. As the film adhering to the ring approached the breaking point, it was proceeded slowly with the adjustments to make certain that the moving system was in its zero position when the rupture occurred. The scale reading at which the ring detached from the latex was recorded after proper correction as the surface tension of the latex at the given temperature. The average of three consecutive readings was recorded discounting the first reading. The surface tension, in milli Newton/meter is calculated as follows:

$$\text{Surface tension, (mN/m)} = M \times N \quad (3)$$

Where, M = reading of the tensiometer, N = a correction factor calculated as follows:

$$N = 0.7250 + \sqrt{[(0.0003678 \times M)/R^2] + P}$$

Where, R = radius of the ring, cm, and P = a constant calculated as follows:

$$P = 0.04534 2 - (1.679S/R)$$

Where, S = radius of the wire of the ring, cm and R = radius of the ring, cm.

Viscosity

A cleaned Ostwald viscometer was mounted vertically in a water bath. Distilled water was poured into the big bulb of the viscometer. Using pipette filler, the solution was sucked up into the smaller bulb. The solution was allowed to flow back into the bigger bulb. The time, t, taken for the solution to pass from the initial mark to the final mark on the bulb was recorded. The time for aqueous solution of the latex sample to pass from the initial to the final mark was determined as explained above. The procedure was repeated for

concentration of latex solutions of 0.002 g/cm³, 0.004 g/cm³, 0.006 g/cm³, 0.008 g/cm³ and 0.010 g/cm³ respectively. A graph of n_{sp}/C against C, was plotted to determine the intrinsic viscosity of the latex.

Crosslink density

About 0.1-0.2 g of latex was weighed and soaked in about 25 ml of toluene for 48 hours, for the latex to swell by absorbing the toluene. The swollen latex was taken out gently and excess solution wiped to free it from toluene absorbed on the surface and was immediately weighed. The crosslink density was calculated by using the Flory-Rhener equation.

Protein content

An amount of 2.0 g of the latex was weighed into a 30 ml digestion flask. A spatula full of Kjeldahl catalyst made up of a mixture of potassium, copper sulphate and selenium powder was added and 20 ml concentrated H₂SO₄ also added and digested until the solution turned colorless. The digest was allowed to cool before being diluted with distilled water to a final volume of 30 ml and then transferred into the Kjeldahl distillation apparatus. A 100 ml conical flask containing 5 ml of H₃BO₄ solution with a few drops of mixed indicator was placed in such a way that the tip of the condenser was immersed in the solution. A 10 ml of sodium hydroxide and sodium thiosulphate mixed solution was added to the test solution. Between 150 ml-200 ml ammonia distillate was collected and 20 ml aliquot titrated against 0.1 N HCl. A blank solution was also titrated with 0.1 N HCl and the titre value subtracted from the sample titre value.

Density of latex

A cleaned relative density bottle was first weighed. The bottle was filled with the latex to the mark (10 ml). It was then reweighed and density calculated.

Moisture content

A cleaned crucible was put in an oven for 15 minutes and then cooled in desiccator after which the weight was taken. About 1 g of the latex was placed inside the crucible and then put inside the oven at temperature of 105 °C for 3 hours. This was repeated several times until a constant weight was obtained.

Rubber content

A known weight (W₁) of the latex sample between (0.1-1.0) g was diluted with 1 ml of distilled water. It was coagulated by adding 2 % acetic acid. The coagulum was pressed into about 1mm sheet thickness. It was leached in water before dried at 70 °C and weighed (W₂). The dry rubber content was calculated as:

$$\text{Rubber content} = \frac{W_1}{W_2} \times 100\% \quad (4)$$

Ash content

A cleaned crucible was put inside a furnace at temperature of 500 °C for 15 minutes. It was then cooled in a desiccator and

the weight recorded. About 1 ml of the latex sample was put in the crucible and reweighed. The crucible containing the sample was put in the furnace at 500 °C for 2 hours. It was then cooled in a desiccator and the weight recorded. The ash content was then calculated.

Refractive index

Using the Abbe Refractometer, the incident prism was opened and carefully cleaned with acetone and allowed to dry. A few drops of the latex sample were placed on the polished surface of the lower refracting prism. The latex sample was scanned using the large adjustment knob until a light and dark image seen. The lower adjustment knob was used to center the boundary in the crosshairs of the telescope and value of the refractive index was read below the boundary to four (4) decimals places. The corresponding sugar content was recorded as percentage (%) sucrose at a temperature of 28 °C. Experimental reading for temperature was corrected using the equation:

$$\eta_D^{20} = \eta_D^T + 0.00045(T - 20 \text{ } ^\circ\text{C})$$

Where, η_D^T is the experimental RI value measured at temperature, T.

RESULTS AND DISCUSSION

Physical appearance of latex

The appearance of the latexes samples varied over a wide range of colors as compared to the HB which was white.

These unique colors might be due to the presence of carotenoids in them. In general, carotenoids absorb wavelengths ranging from 400-550 nanometers (violet to green light). This causes the latexes to exhibit different colors stemming from pale yellow to dark red. For example, the color of *Trilepisium madagascariensis*, is red, *Alstonia boonei*, is milky white *Antiaris toxicaria* is brown (figure 1). Carotenoids contain mainly conjugated hydrocarbon double bonds with no oxygen and has chemical formula $C_{40}H_{56}$ (Pallardy, 1991).

FT-IR analysis of latex

FT-IR for the latex samples are shown in Figure 2. The spectra of all the latex samples did not show significant difference. This is due to the fact that the polyisoprene unit is common to all the latex samples (Cornish *et al.*, 2002). The broad peak from 3340.17 to 3368.33 cm^{-1} indicates the presence of OH functional group since latex sap contain between 55 to 65 % water (Jayanthi *et al.*, 2005; Zhao *et al.*, 2010). Peak around 2963.61 cm^{-1} indicates terminal (vinyl) C-H stretch. The band at 1637.06 cm^{-1} shows the presence of C=C alkenyl bond in the natural latex. The band at 1067.05-402.89 cm^{-1} shows vinyl C-H trans out-of-plane bond. The peak at 1388.58 cm^{-1} indicates CH_3 bend. The peaks from 1450.06-1377.4 cm^{-1} shows the presence of methyl CH_3 and CH_2 bend. Small peaks at 1087.20, 1048.69, 1048.60 cm^{-1} indicate the skeletal C-C vibrations.

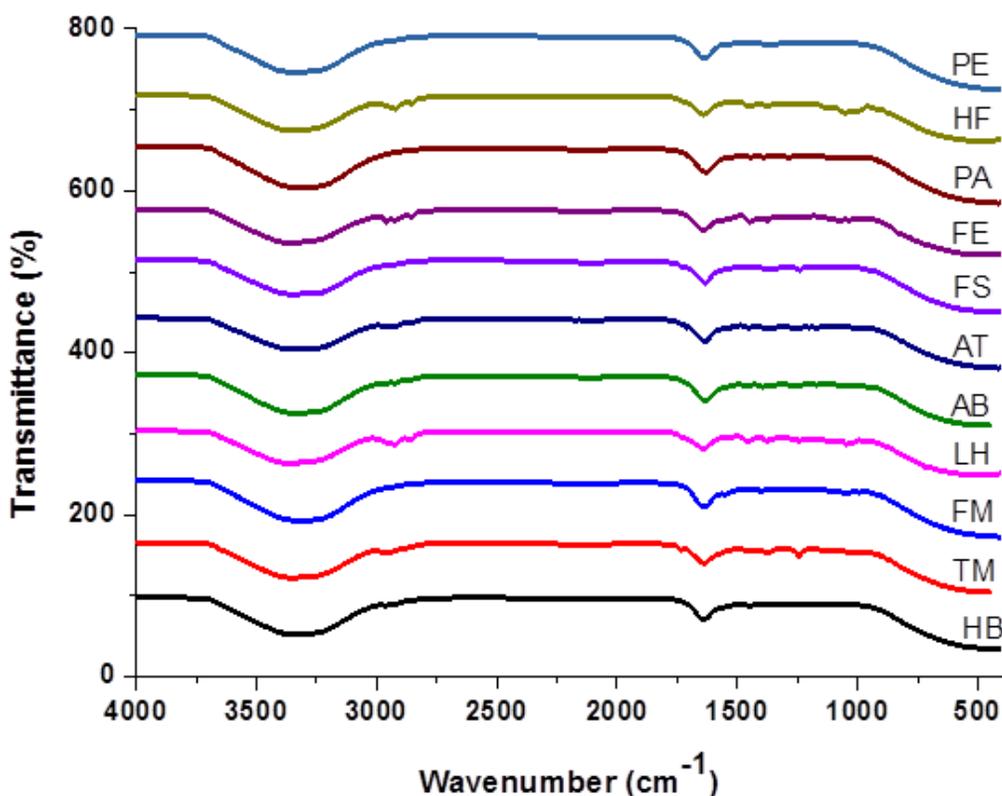


Fig. 2: FT-IR spectra of the latexes sampled

Table 1: Physicochemical parameters of the latexes sampled

Name of Latex	TS	AC	MC	PC	RC	CoC	ST	D	CD	pH
	%	%	%	%	%	%	mN/m	g/cm ³		
<i>Alstonia boonei</i>	47	0.9	25.02	1.73	31.63	12	60	1.0278	0.71	6
<i>Antiaris toxicaria</i>	22.6	2.9	30.1	9.55	19.6	6	68	1.0549	0.33	6
<i>Funtumia elastica</i>	49.36	2.95	55.8	5.82	48.31	1	55.1	0.972	1.36	6
<i>Holarhena floribunda</i>	26.92	1.83	34.29	0.86	25.45	1	54	0.9015	0.18	6
<i>Pycnanthus angolensis</i>	17.07	0.28	13.89	1.62	19.44	2	72.3	0.079	0.73	3
<i>Trilepisium, madagascariensis</i>	39	0.2	38.51	11.53	20.75	10	63.5	0.9209	0.82	6
<i>Ficus. Vogiliana</i>	47.5	1.3	21.87	9.56	18.75	9	65.3	1.0555	0.13	6
<i>Ficus mucoso</i>	50.5	2.5	15.97	5.87	7.22	1	58	1.0579	0.92	8
<i>Landolphia hirsuta</i>	88.4	0.1	12.43	1.24	1.92	13	55	1.2026	0.15	6
<i>Parquetina eliptica</i>	21.72	0.98	11	3.35	25.86	6	40.5	1.209	0.13	6
<i>Hevea brasiliensis</i>	14.98	0.41	13.98	1.9	56.18	1	49	1.003	0.08	7

Where, TS = Total solids, AC = Ash contents, MC = Moisture content, PC = Protein content, RC = Rubber content, CoC, Coagulum content, ST = Surface tension, D = Density, CD = Crosslink Density

Physicochemical parameters of latex

A physical property of a sample is a property that may be seen and measured without change in chemical identity of the sample. In this experiment, physical properties such as total solids, density, rubber content as well as chemical properties of the latexes were determined. Table 1 compares the total solids, ash, moisture, protein and rubber contents of the latexes sampled to *Hevea brasiliensis*, the reference sample. Total solid is the non-volatile part of the latex and ingredients that are non-volatile at the temperature at which the volatility test is run. From table 1, the lowest total solid content is 14.98%, which is the reference sample and the highest, *Landolphia hirsuta*, being 88.40%. Comparing the values to literature value of 40.1%-41.0% total solid reported by (Akinilabi *et al.*, 2005), none of the latexes sampled fell within the literature value. The solids present in these latexes are not specific chemical compounds, but a diversely wide collection of dissolved and particulate matter causing the differences in the total solid content of the latexes (Danwanichakul *et al.*, 2012). High total solid content of natural latex are suitable for making molds for casting plaster, cement, wax, for stabilizing desert soil for agricultural purposes.

Ash content

Ash content is the amount of inorganic part of the latex. It includes metal oxides, salts and ions such as Na⁺, K⁺, Ca²⁺. From table 1, *Landolphia hirsuta* has the lowest ash content of 0.10 %, and *Funtumia elastica* with highest ash content of 2.95 %, while the reference sample, Hevea, has 0.41 % value of ash content. Among the latexes, *Trilepisium madagascariensis* had the value of 0.28 % close to the Hevea. Literature value reported by (Manoel, *et al.*, 2005) and (Sakdapipanich *et al.*, 2012), showed an ash content of 0.2 %

while (Jayanthi, *et al.*, 2005) also reported an ash content between 0.1 %-0.5 %, of which the reference sample, *Trilepisium madagascariensis*, *Pycnanthus angolensis* and *Landolphia hirsuta* fell within. The differences in ash content can be attributed to climatic changes, soil condition, tapping process (Jayanthi *et al.*, 2005). If the ash content is greater than 15 % of the total solids in the latex, coagulation occurs very fast.

Moisture content

The moisture content is the amount of water contained in the latex. From table 1, *Funtumia elastica* has the highest moisture content of 55.80 % and *Parquetina eliptica* with the lowest moisture content of 11.76 %. The reference sample, has moisture content of 13.98 % and *Pycnanthus angolensis* showed a close value of 13.89 %. Comparing these values with literature value of 55.0 %-65.0 % reported by (Jayanthi *et al.*, 2005; Zhao *et al.*, 2010) shows that the moisture content of *Funtumia elastica* falls within the reported values. The differences may be due to different climatic conditions and experimental procedures. Moisture content is also directly proportional to dielectric constant. Dielectric is the property of transmitting electric force without conduction.

Rubber content

Rubber content is the ratio of the weight of dry substance solidified by the acid to the weight of latex. It determines the cost of the rubber. From table 1, the rubber content of the reference sample (*Hevea brasiliensis*) was the highest, 56.18 % while *Landolphia hirsuta* has the lowest rubber content of 1.49 %. However, the value of 48.31 % for *Funtumia elastica*, was close to the reference sample. Comparing these values to literature value of 30.0%-40.0% of rubber content (Jayanthi *et al.*, 2005) shows that one of the samples (*Alstonia boonei*), 31.63 % fell within the range while ten of the samples fell

outside the range. The differences in dry rubber content of the latexes are due to difference in strains of rubber tree, true ages, climatic conditions, tapping intensity, chemical stimulation (Zhao *et al.*, 2010). Generally, the rubber content of the latex samples was lower than the total solids content which confirms the fact that the rubber content of latex is a proportion of the total solids. However, samples from *Pycnanthus angolensis*, *Parquetina eliptica* and *Hevea brasiliensis* did not follow this trend. A similar observation for *Hevea brasiliensis* has been reported earlier.

Protein content

Natural rubber latex (*Hevea brasiliensis*) contains about 1-1.5 % or 2.0%-3.0 % protein content (Jayanthi *et al.*, 2005). Comparing these values to the protein content of *Hevea brasiliensis*, 1.90 % in table 1, shows that it is within the literature value. Also, *Landolphia hirsuta* with protein content of 1.24 % fell within the literature value reported. *Hollarrhena floridunda* has the lowest protein content of 0.86 % and *Trilepisium madagascariensis*, has the highest protein content of 11.53 %. The variation in protein content of the latexes may be due to physiological conditions of the trees. Amount of protein in latex glove is vital as many people are allergic or sensitive to protein in latex (Hasan *et al.*, 2011). Hence, latex from *Hollarrhena floribunda* can be used to produce latex gloves.

Coagulum content

Coagulum content is the particle or substance remained on a 180-micron sieve under the conditions of the test and this includes particles of polymer and coarse foreign particles. *Landolphia hirsuta* has the highest coagulum content of 13 % while *Funtumia elastica*, *Ficus mucoso*, *Hollarrhena floribunda*, and the reference tree (*Hevea brasiliensis*) had the lowest of 1% as can be seen in table 1. These variations are attributed to differences in particle size, tapping tools used during harvesting and method of storage.

pH

A pH is a numeric value that determines the acidity or alkalinity of solution. It is the negative logarithm to base 10 of the activity of hydrogen ions concentration measured in units of mol/dm³ (Kieran *et al.*, 2006). From table 1, the pH of the various latexes ranged between 3 and 8. Those with pH from 3 to 6 fall within the acidic region and those with pH 7 are in the neutral region while those with pH 8 fall in the basic region. Among the latexes sampled, eight were in the acidic region. One in basic region and one in neutral region. *Hevea brasiliensis*, gave a pH value of 7 which is neutral. From literature (Jayanthi, 2009), latex with pH from 3-5 coagulates very fast upon exposure to air and also leads to putrefaction (rotting). Latex with pH from 7 and above is stable for a long time without coagulation. Freshly harvested *Hevea* latex is virtually neutral having a pH within a range of 6.5-7.0. Latex with pH greater than 7 have high stability due to the improved the basic electrostatic repulsion between the colloidal rubber particles. Industrially, this is achieved by the by the addition of ammonia to the freshly tapped latex. From

this research, *Ficus mucoso* is basic (pH 8) and therefore can replace *Hevea brasiliensis* in industrial processes. The differences in the pH values of the latexes sampled are due to factors such as acidity of the soil, amount of rainfall in the area (Petra *et al.*, 2000).

Cross-link density

The cross-link density values in table 1, shows that *Funtumia elastica* had the highest cross-link density of 1.36 while *Hevea brasiliensis* had the lowest cross-link density of 0.08. The degree of crosslinking has many effects on rubber and it is affected by the nature of solvent. There is greater interaction between solvent and polymer molecules if the solvent is similar in chemical properties. Hardness or modulus increases with increase in crosslinking. Solvent swelling decreases with increase in crosslinking fatigue and cracking increases with increase in crosslinking (Hong, 2008).

Density

Density is defined as the mass per unit volume of that substance (Patterson *et al.*, 1994). *Parquetina eliptica* had the highest density of 1.205 g/cm³ and *Pycnanthus angolensis* had lowest density of 0.079 g/cm³. The reference sample, (*Hevea brasiliensis*), has a density of 1.003 g/cm³.

Surface tension

Surface tension is the energy required to increase the surface area of a liquid by a unit area. From table 1, *Pycnanthus angolensis* has the highest surface tension value of 72.30 mN/m while *Parquetina eliptica*, the lowest value of 40.5 mN/m. *Hevea brasiliensis* has the value of 49.0 mN/m. The surface tension results because of the imbalance of intermolecular attractive forces or the cohesive forces between molecules. The differences in the surface tension values are attributed to the fact that different latexes have differences in high surface free energy. The surface free energy forces the latex into a spherical shape, which breaks up into tiny semi-spherical pools of liquids separated by dry areas of the substrate. The small value of surface tension is due to the low affinity of the surface of the latex. Also, the lower the surface tension value, the more stable the latex and hence, the higher the ability for wetting. Surface tension also affects the adhesion property of the latex (Hong, 2008).

Viscosity

The viscosity of a material is the resistance to the flow of that material. The solute's contribution to viscosity depends on intrinsic viscosity of the solution (Kwaanbwa *et al.*, 2006). The polymer molecular weight is related to intrinsic viscosity by Mark-Houwink's equation, $[\eta]=KM^\alpha$. Intrinsic viscosity v is high for a good solvent since there is better polymer-solvent interaction within a given temperature (Onyeagoro *et al.*, 2012). The viscosity of the various latexes sampled was done using distilled water as a solvent since most of the latexes were soluble in it. A plot of reduced viscosity, n_{sp}/C against concentration, C was done to determine the intrinsic viscosities of the various latexes at a temperature of 28 °C.

Table 2: Intrinsic viscosity of the latexes sampled

Name of latex tree	Intrinsic viscosity, [η]
<i>Alstonia boonei</i>	0.002
<i>Antiaris toxicaria</i>	0.76
<i>Funtumia elastica</i>	0.775
<i>Hollarhena floribunda</i>	1.25
<i>Pycnanthus angolensis</i>	1.535
<i>Trilepisium madagascariensis</i>	1.075
<i>Ficus vogiliana</i>	0.5
<i>Ficus mucoso</i>	0.685
<i>Landolphia hirsuta</i>	0.62
<i>Parquetina eliptica</i>	1.42
<i>Hevea brasiliensis</i>	1.19

Table 3: Refractive index of latex

Name of latex tree	Refractive index
<i>Alstonia boonei</i>	1.405
<i>Antiaris toxicaria</i>	1.6785
<i>Funtumia elastica</i>	1.674
<i>Ficus mucoso</i>	1.3575
<i>Hollarhena floribunda</i>	1.673
<i>Landolphia hirsuta</i>	1.3026
<i>Pycnanthus angolensis</i>	1.358
<i>Trilepisium madagascariensis</i>	1.67
<i>Parquetina eliptica</i>	1.595
<i>Hevea brasiliensis</i>	1.673

From table 2, the intrinsic viscosity of 1.190 of the reference sample (*Hevea brasiliensis*) is close to that of *Trilepisium madagascariensis* with intrinsic viscosity of 1.075 as compared to the rest of the latexes. The higher the intrinsic value, the bigger the molecular mass, since intrinsic value is directly related to the molecular mass (Onyeagoro et al., 2012).

Refractive index

Refractive index describes how light travels through a medium or determines the extent to which amount of light is absorbed by a material. The amount of scattered light depends on concentration, temperature and the particle size of the latex. The higher the concentration, the higher the refractive index (Ahmed, 2016). From table 3, the refractive indices of the samples were determined at a temperature of 28 °C. The varying refractive indices of the latexes sampled are an indication of the different particle sizes of the latexes. *Alstonia boonei* has the lowest refractive index of 1.405 while *Antiaris toxicaria* has the highest value of 1.6785.

CONCLUSIONS

Ten latex samples were characterized to determine their physicochemical properties. The study revealed that latexes stored in the refrigerator at 20 °C were stable and did not coagulate throughout the analyses without the use of preservatives such as ammonia. Also, latexes with pH from 6-8 showed higher stability when brought to the laboratory for analyses were done. The ten latex samples were characterized to determine their physicochemical properties as compared to *Hevea brasiliensis*. Considering rubber content, coagulum content, surface tension as properties for a specific application, *Funtumia elastica* can be an alternative to *Hevea brasiliensis*.

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