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Physical and Chemical Characterizations of Rubber Latex Cup Bottom Oil

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Abstract

Rubber latex is an important economic resource. However, the residues from its harvesting are thrown away, even though they contain lipids that can be recycled. This recovery of the residues from the bottom of the cup requires first and foremost their characterization. The aim of this study is therefore to determine the main physical and chemical characteristics of rubber latex cup bottom oil. Oil's physical parameters determination shows that it has a density of 951 $kg\cdot m^{-3}$, a kinematic viscosity of 48.57 cSt and a water content of 0.0845%. Chemical parameters, meanwhile, indicate that this cup bottom residue has a fat content of 95.96%, an acid number of 2.805 mg KOH/g and an iodine number of 92.42 g I_2/100g. Therefore, rubber latex cup bottom oil can be used in the formulation of biofuels, biolubricants, paints, varnishes, alkyd resins, polishing oils, soaps, and insecticides.

Keywords

Rubber Latex Cup Bottoms Oil, Density, Viscosity, Characterizations

1. Introduction

Since the advent of the industrial revolution, daily energy consumption has increased alarmingly. This has resulted in advances in lifestyle, technology, and transport. This progress has come from the use of fossil oils sources, causing ever-increasing environmental pollution however their prices rise [1] [2]. The instability of oil prices and the measures taken to reduce the increase in greenhouse gas emissions are the main factors promoting the development and use of environmentally friendly energies [3] [4]. From energy efficiency point of view, biofuels are a renewable energy source, and their use helps to reduce energy dependence on fossil fuels. The most used biofuels for transport in the world are biodiesel and bioethanol [5]. However, there are other options, such as pure vegetable oils [6]. Vegetable oils are produced from a wide range of oilseed crops. Some of these oils have already been evaluated as substitutes for diesel fuels [7]-[10]. They are by nature good substitutes for fuel oils and gasoils, with potential blending rates of up to 100% [11]. They can be used in an unmodified diesel engine or with minor modifications to the fuel intake system [8] [12]. The production of vegetable oil is much easier than that of biodiesel because it involves fewer processes and less energy consumption. However, the use of foodstuffs as biofuel or for biofuel production has a negative impact on food security [13]. Indeed, in its report, the FAO (2011) indicated that the surge in demand for agricultural raw materials for biofuels has contributed to a rise in food prices, threatening the food security of the poorest in urban and rural areas [14]. It is therefore necessary to find agricultural species that can manage the problem of food and land. Latex cup bottom oil emerges as one of the potential sources that can contribute to future energy demand. Latex is the main product of rubber tree cultivation. It is a major source of natural rubber [15]. It is of great economic interest to many countries around the world. It is the main source of commercially exploited natural rubber [15]. It is indispensable in countless industrial applications: gaskets, surgical gloves, rubber, footwear, with properties of elasticity and impermeability that make it an irreplaceable material in certain uses [16]. The genus Hevea belongs to the *Euphorbiaceae* family and is a well-defined taxonomic group in which, to date, ten species have been recorded [17]-[19]. Of these, *Hevea brasiliensis* is the most important species. With its twenty or so subspecies, it has the highest yield (1.5 to 3 t/year per hectare) for natural rubber production [20]. It produces large quantities of high-quality latex [18] [21] [22]. The growing demand for this raw material has led to the launch of numerous studies aimed at increasing latex production [23]. Since 2020 Côte d'Ivoire has become the world's fourth largest rubber producer [24].

The latex can be harvested in liquid form, just after bleeding, or in solid form if the latex is coagulated in the cup [18] [22]. However, harvesting latex in its solid form requires great dexterity. In fact, extracting it from the cup requires a certain amount of finger force, by rotation, to detach it [18]. It is therefore not completely collected. After harvesting, the tapper uses a curette to scrape the residue from the bottom of the cup in order to clean the container. These residues are thrown away, whereas they contain recoverable elements [18] [25]. The valorization of a fluid in the energy field requires a minimum of physical and chemical characterization. It is within this framework that this study falls, which aims to determine the physical and chemical characteristics of the oil from the bottom residue of rubber latex cups with a view to its valorization in the energy sector.

2. Materials and Methods

2.1. Raw Material

The raw material studied is oil produced by industrial processing of the residues of the bottom of rubber tree latex cups. It is produced by Bayan Industry Company (BIC) (Abidjan-Côte d'Ivoire). This fluid was obtained by collecting the residue, drying it and grinding it.

2.2. Reagents and Solvents

The 98% purity Wijs reagent was purchased from Acros Organics. Soluble starch (99%), glacial acetic acid (100%) and phenolphthalein (99.5%) were purchased from Merck. Chloroform (99.2%) was purchased from Prolabo, ethanol (96%) from Analar, sodium thiosulphate (99%) from Sds, potassium hydroxide (85%) from Chem-Lab, carbon tetrachloride (99%), hydrochloric acid (37%) from Riedel-de Haën, hexane (99.17%) from Panreac, potassium iodide (99%) and methanol (99%) from Carlo Erba.

2.3. Methods

2.3.1. Determination of the Density

The density and specific gravity of the oil was determined in accordance with NF EN ISO 6883 [26]. Volumes of 5 mL of dry oil and water were weighed. The masses determined for the test plugs and distilled water respectively were used to determine these parameters, at the ambient temperature of the laboratory (29˚C).

Relation (1) was used to calculate the density ρ_h (kg·m^{-3}) of the cup-bottom oil.

$$\rho_h = \frac{m}{V} \tag{1}$$

where, m, the mass of the oil sample (kg) and V, the volume of the oil sample (m^3).

2.3.2. Determination of the Kinematic Viscosity

Viscosity is one of the oil parameters that directly influences the correct operation of diesel engines. It was determined using a falling ball viscometer (Thermo Scientific) fitted with a thermostatic bath (Lauda) [27]. The measurement variable used is the time taken for the ball to move t (measured by an electronic chronometer) over a given distance. The measurements were taken at 38˚C. The cylindrical tube of the viscometer was filled with oil, then the ball was dropped into the tube. The relationship (2) was used to calculate the dynamic viscosity η of the oil:

$$\eta = k\left[\rho - \rho_h\right]t \tag{2}$$

With

k: the ball constant (mPa·s·cm^3/g·s)

t: the falling time of the ball (s)

ρ and ρ_h the respective densities of the ball and the oil (g·cm^{-3})

The kinematic viscosity of a fluid is the ratio of its dynamic viscosity η to its density ρ (relationship 3) and is expressed in m^2/s or cSt.

$$v = \frac{\eta}{\rho_h} \tag{3}$$

2.3.3. Determination of Cloud Point

The cloud point was determined in accordance with ASTM D 2500 [28]. After preliminary heating in a water bath, the sample was immersed in a freezing bath (ice + sodium chloride crystals) and then cooled at a specified rate. The temperature at which the first crystals appear corresponds to the cloud point.

2.3.4. Determination of Water Content

Moisture content is an important parameter for guaranteeing sufficient quality of vegetable oil for use as biofuel. It was determined in accordance with international standard ISO 662 [29]. The method involves measuring mass loss by weighing the sample after oven drying at 103˚C ± 2˚C for 24 hours. 10 g of the oil sample was weighed into a ceramic capsule and dried in an oven at 103˚C ± 2˚C for 24 hours. After cooling in a desiccator, the sample was weighed again. The water content (T) is given by relationship (4).

$$T = \frac{m_1 - m_2}{m_1 - m_0} * 100 \tag{4}$$

where, m_0, the mass (in g) of the empty capsule; m_1 and m_2 the masses (in g) of the capsule + sample before and after drying respectively.

2.3.5. Determination of the Iodine Value

The iodine value was determined in accordance with standard NF ISO 3961 [30]. The method consists of dissolving the test sample in solvent and adding Wijs reagent. After a given time, potassium iodide and water are added, followed by titration of the liberated iodine with a sodium thiosulphate solution. 10 mL of carbon tetrachloride and 10 mL of Wijs' reagent are added to a 250 mL flask containing 2 g of test sample. The mixture was kept in the dark for 1 hour. 100 mL of distilled water was then added to the mixture, which was determined iodometrically using a 0.1 M sodium thiosulphate solution, with stirring. A blank test was carried out under the same operating conditions. The iodine value (I_I in g of I_2/100g) is calculated from relationship (5).

$$I_I = \frac{12.6 \times C \times (V_1 - V_2)}{m} \tag{5}$$

With, C, the concentration of the sodium thiosulphate solution (mol/L); V_1 and V_2, the volumes (mL) of the sodium thiosulphate solution used for the blank test and for the oil respectively.

m is the mass of the test sample (g) and 12.69, the number of grams of iodine corresponding to 1 mL of thiosulphate.

2.3.6. Determination of the Peroxide Value

The peroxide value is an index of rancidity and therefore provides information on the quality and stability of the oil. The peroxide value was determined in accordance with the international standard ISO 3960 [31]. The principle is based on the iodometric determination of the oil sample dissolved in a mixture of glacial acetic acid/chloroform. To a 250 mL conical flask containing 2 g of the test sample, 30 mL of a glacial acetic acid/chloroform mixture (3:2 v/v) is added. The mixture is stirred until the sample is dissolved. 0.5 mL of a saturated potassium iodide solution and 30 mL of distilled water were added. The mixture was titrated with a 0.1 M sodium thiosulphate solution. A blank test was carried out under the same operating conditions. The peroxide value (I_P (meq O_2/kg)) is calculated from relationship (6).

$$I_P = \frac{[V_1 - V_2] \times 10}{m} \tag{6}$$

V_1 and V_2, the volumes of sodium thiosulphate solution used for the sample and blank respectively (mL) and m, the mass of the test sample (g).

2.3.7. Determination of the Acid Value

Acid values give an indication of the age and quality of the oil or fat. The acid value has been determined in accordance with the international standard ISO 660 [32]. The principle is to determine the level of free fatty acids present in the oil by titrimetry using a solution of alcoholic potash. 2g of oil is dissolved in 10 mL of a mixture of diethyl ether and ethanol (1:1 v/v). After neutralization with a potassium hydroxide solution, the mixture was titrated with a 0.5N solution of ethanolic potash in the presence of phenolphthalein. A blank test was carried out simultaneously under the same operating conditions. The acid value (I_A (mg KOH/g)) is determined from relationship (7).

$$I_A = \frac{[V_1 - V_2] \times N \times 56.1}{m} \tag{7}$$

where V_1 and V_2 are the volumes of ethanolic potash solution used for the sample and blank respectively (mL); m is the mass of the test sample (g); N is the normality of the 0.5 N ethanolic potash solution and 56.1 is the molar mass of KOH (g/mol).

2.3.8. Determination of the Saponification Number

This index was determined using the international standard ISO 3657 [33]. The principle consists of neutralizing the free fatty acids in the oil while hot with an excess of alcoholic potash solution, then titrating this excess with a hydrochloric acid solution. 25 mL of the alcoholic potash solution is added to a conical flask containing 2 g of the test sample. The mixture was refluxed for 1 hour. The soapy solution obtained was titrated while hot with a hydrochloric acid solution, in the presence of phenolphthalein. A blank test was carried out under the same operating conditions. The saponification number (I_S mg KOH /g) is calculated from relationship (8).

$$I_S = \frac{[V_1 - V_2] \times N \times 56.1}{m} \tag{8}$$

With: V_1 and V_2, the volumes of HCl solution used for the sample and blank respectively (mL); m, the mass of the test sample (g); N, the normality of the HCl solution and 56.1 the molar mass of KOH (g/mol).

3. Results and Discussion

3.1. Physical Characteristics of Cup Bottom Oil

Table 1 shows the physical parameters of rubber latex bottom-of-cup oil.

Table 1. Physical characteristics of the oil.

Parameters	Kinematic viscosity at 38˚C (cSt)	Density at 28 ˚C (kg/m^3)	Water content (%)	Point of trouble (˚C)
Values	48.57	951	0.0845	−1.5

The oil density value of 951 kg/m^3 clearly shows that the sample is of vegetable origin. This value is between 900 - 960 kg/m^3, and this interval is the one in which the density of the majority of vegetable oils falls [34]. Furthermore, the density of the oil studied is very close to that of castor oil (ρ = 952.5 kg/m^3) [35]. It should be noted that this type of oil is used as varnishes, paints and biolubricants in heavy machinery working at very high temperatures [36]. The kinematic viscosity of the oil studied (48.57 cSt) is close to that of jatropha oil (49.9 cSt) [37]. As this oil is used to produce biofuels, the cup bottom oil could be used. Viscosity is one of the most important characteristics of biodiesel. It affects fuel drop size, jet penetration, atomization quality, spray characteristics and combustion quality [38]. Very high or very low fuel viscosity affects the engine [39]. For example, if the viscosity is very low, there will be insufficient lubrication, which will increase wear and leakage. A more viscous fuel will form larger droplets during injection, affecting combustion quality and leading to increased exhaust emissions [40]. To remedy this, preheating is sufficient [41]. Also, the presence of water in a fuel is detrimental as it promotes microbial growth, corrosion of tanks and filters, disturbs ignition and reduces the efficiency of stationary engines [34]. A high value would require heating before use, to enable this oil to meet fuel specifications. The value determined for cup bottom oil is 0.0845%. As this value is low, cup bottom oil could be used directly as a biofuel without drying.

The cloud point found in this work is −1.5˚C. This value is of the same order of that of sweet almond oil (*Prunus amygdalus*) (−2˚C) and jatropha oil (−2˚C) [35] [40] [42]. The oil studied in this work could be used in the formulation of biolubricants and biofuels.

3.2. Chemical Characteristics

Table 2 gives a summary of chemical characteristics of rubber latex cup bottom oil.

Table 2. Chemical characteristics of the oil

Parameters	Iodine index (g I_2/100g)	Saponification index (mg KOH/g)	Acid index (mg KOH/g)	Peroxide value (meq O_2/kg)
Values	92.42	191.72	2.805	9.95

The cup bottom oil analyzed in this study has a peroxide value of 9.95 meq O_2/kg. This value indicates that the oil has deteriorated and is unfit for consumption [22]. The I_P of a rancid oil is between 10 - 20 meq O_2/kg [43]. It has an acid value of 2.805 mg KOH/g. This value is lower than the limit value of 3 mg KOH/g recommended by the West African pre-standard [34]. Indeed, high acidity can cause severe corrosion of the fuel system of a combustion engine [44]. Many researchers have reported that free fatty acids (FFAs) above 3% in oil require pretreatment for optimal conversion to biodiesel, as high FFAs result in the oil being lost as soap rather than biodiesel [45]. This index is close to those of sweet almond (*Prunus amygdalus*) (2.811 mg KOH/g) and African star apple (*Chrysophyllum albidum*) (2.88 mg KOH/g) oils [42]. These oils could be used for industrial applications in the production of biofuels and biolubricants. The iodine value gives an idea of the unsaturation of an oil. It represents the degree of unsaturation [44]. From a fuel quality point of view, the more saturated the oil, the better it is. Or the lower its index, the better it is. The value of the iodine index (92.42 g I_2/100g) between 50 and 100 shows that this oil is monounsaturated, semi-drying and of the oleic type [11] [34]. This semi-drying oil could therefore be used in the production of alkyd resins (binders for paints and varnishes) and shoe polishes [22]. It could also be used as a biofuel and lubricant [34] [39] [46]. According to standard EN14214 (European Committee for Standardization) [47], as the iodine value is less than 120 g I_2/100g, this oil could be used as a raw material for biodiesel production [42]. The saponification value (191.72 mg KOH/g of oil), which is higher or lower, shows that this oil could be used to make soaps. This is the case for oils from buriti palm and macauba pulp, which have saponification numbers of 190 and 192 mg KOH/g respectively [46].

4. Conclusion

The main objective of this study was to characterize the Rubber Latex cup bottom oil from rubber latex with a view to its possible use. The results obtained enabled this fatty substance to be classified as a vegetable oil unsuitable for consumption, based on its density (951 kg·m^{-3}) and its peroxide value (9.95 meq O_2/kg). In addition, its iodine index (92.42 g of I_2/100 g) places it in the category of semi-drying, monounsaturated, oleic-type oils. The other parameters determined, such as kinematic viscosity (48.57 cSt), cloud point (−1.5˚C), saponification number (191.72 mg KOH/g) and acid number (2.805 mg KOH/g), highlighted the high potential of this oil. This study shows that the oil from the bottom of rubber latex cups could be used in the formulation of biofuels, biolubricants, paints, varnishes, alkyd resins, soaps, polishing oils, and insecticides.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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