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The Potential Capacitance of Shea Butter

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Authors' contributions

This work was carried out in collaboration between both authors. Author FOO initiated the research and supervised, surveyed literature, analyzed the result and revised the first and second form of the manuscript. Author SA surveyed literature and did the experimental work. Both authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

In this paper, the potential capacitance of shea butter (SB) was studied using thermal influenced by varying the temperature between 30°C and 80°C, and distance between the plates from 1 cm to 3 cm. Though different samples were not used for this research, the qualities of various SB in term of physical and chemical composition are related. The SB exhibit dielectric property which satisfies the common law due to short distance effect that is inversely proportional to the amount of charge stored using a unique cross-sectional area of the plates. The temperature was noted to reduce the potential capacitance as it increases while short distance allows high capacitance.

Keywords: Capacitance; temperature; optimal; voltage.

1. INTRODUCTION

There are several important properties such as dielectric strength, resistivity, flash point, kinematic viscosity and water content used in grading oil [1] for its uses. Mineral oil has found use as an insulator for the transformer, but nowadays, coconut oil has been shown to possess all the properties needed to function as an environmentally friendly replacement for mineral oil [2]. Shea nut oil is a variety of tropical oil, which also includes palm, cocoa and coconut

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oil. Under the alternating current condition, the field distribution is dominated by the permittivity of the dielectric and the conductivity is regarded as only being significant in its contribution to losses in the system. However, the formation of bubbles as a result of Joule heating which is dependent on the conductivity has been proposed as a mechanism for liquid breakdown [3] and stability lose due to high temperature over a long period [4]. It is known that the breakdown field is a non-linear function of the inter-electrode gap, and higher breakdown field can be achieved in shorter gaps stressed with impulsive and ac voltages (this can potentially be explained by the smaller number of impurities in shorter gaps) [5]. Values of the effective mobility of the charge carriers in liquids can be obtained from pre breakdown current-voltage (I-V) characteristics, measured in a point-plane electrode topology [6]. But, the potential capacitance of tropical oil has not been taking into consideration.

Shea [*Vitellaria paradoxa Gaertn.*] nuts are frequently used in Africa to extract oil called "Shea butter" SB. It is well known for its multiple uses in cosmetic, pharmaceutical, and food industries. Some antioxidant and anti-inflammatory properties of SB were also reported [7-11]. The first SB quality criteria required in the market are the free fatty acid (FFA) content and the peroxide value. Cosmetic and pharmaceutical industries require this first quality of SB (FFA content < 1% and peroxide value < 10 meq/kg) while food industries require the second quality of SB (FFA content < 3% and peroxide value < 15 meq/kg) [12]. To some people, butter colour is the main criterion [13]. The samples also share similar chemical compositions while the physical properties are consistent and the moisture content decreases as the temperature increases [14]. Shea butter physicochemical characteristics are reported as follow: melting range (34 – 36°C); iodine value (58.53%); saponification value (180.37%); and unsaponifiable matter content (7.48%) [15]. Shea butter physicochemical characteristics are said to be influenced by the roasting time because the acid, peroxide, iodine index and unsaponifiable content varied considerably with roasting time [16]. This unsaponifiable fraction is composed of bioactive substances that are responsible for its medicinal properties [17,18].

From capacitance formula,

$$Q = CV \quad (1)$$

Where Q is the charge, C is the capacitance and V is the voltage passed.

$$C = \frac{\mathcal{E}d}{A} \quad (2)$$

where ($\mathcal{E} = \mathcal{E}_r \times \mathcal{E}_o$), $\mathcal{E}$ is the permittivity, $\mathcal{E}_r$ is the relative permittivity, $\mathcal{E}_o$ is the permittivity of free space, "d" is the distance between the plates, "A" is the cross-sectional area.

In this paper, we study the potential capacitance of SB by varying the temperature and distance between the copper plates used.

2. MATERIALS AND METHODOLOGY

The Shea butter was bought from Gwagwalada market in Abuja. It was placed and measured in a beaker with a weighing balance and the mass of the Shea butter was recorded. After that, the beaker containing the Shea butter was placed on a heat source and the Shea butter was melted at its flashpoint with the volume recorded. Two copper (Cu) plates measuring 5 cm by 5 cm used as electrodes were suspended into the melted Shea butter and was hanged to the retort stand. The distance between the plates was varied using 1 cm, 2 cm and 3 cm respectively, the temperature was also varied from 30°C to 80°C with an interval of 10°C. The two plates suspended into the melted Shea butter were then connected to the capacitance meter with the aid of connecting cable and the thermometer was inserted in the melted butter to monitor the temperature. The readings were repeated for each temperature and recorded.

3. RESULTS AND DISCUSSION

Tables 1, 2 and 3 show the repeated readings taken before plotting the mean capacitance against temperature and distance.

Fig. 1, shows the potential capacitance (stored charge) by SB which is a determinant for its use as a dielectric liquid. At the distance of 1 cm, the capacitance values are very significant than that of higher distances between the plates. This depicts the fact that a very short distance to 1 cm would have a higher capacitance which satisfies the equation $C = \frac{\mathcal{E}d}{A}$. At temperature 30°C which is slightly lesser than the flashpoint (34°C) of SB, the capacitance values were observed to be greater than that of other temperatures and the viscosity decreases due to weakened molecular bond at higher temperatures and loss of potential capacitance.

Table 1. The readings on the capacitance meter at 1 cm distance apart

Temperature (°C)	C_1(pF)	C_2(pF)
30.0	55.4	55.0
40.0	55.1	54.8
50.0	54.8	54.5
60.0	54.3	54.0
70.0	54.1	53.9
80.0	53.8	53.6

Table 2. The readings on the capacitance meter at 2 cm distance apart

Temperature (°C)	C_1(pF)	C_2(pF)
30.0	51.2	51.3
40.0	50.9	51.0
50.0	50.4	50.4
60.0	50.2	50.1
70.0	49.7	49.8
80.0	49.3	49.2

Table 3. The readings on the capacitance meter at 3 cm distance apart

Temperature (°C)	C_1 (pF)	C_2 (pF)
30.0	51.6	51.7
40.0	49.4	49.5
50.0	49.3	49.4
60.0	48.8	48.9
70.0	48.8	48.7
80.0	48.5	48.6

Fig. 2 shows that the influence of distance is optimal at the least temperature as shown at 30°C. The drop in capacitance value is proportional to the distance. This implies that, at a much lesser temperature such as room temperature and little distance, the potential charge of SB will be more than the plotted peak. Also, the capacitance value of SB at 30°C and 40°C for 1 cm are 55.05 and 54.95 pF respectively which are very close. At 50°C the values for various distances decreases proportionally with distance.

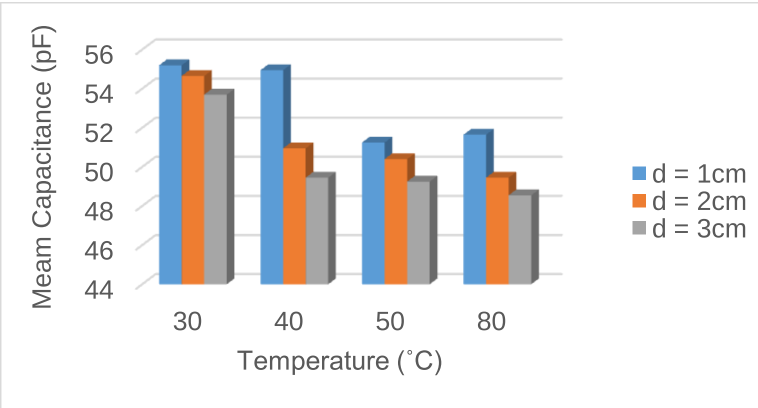

Fig. 1. Mean capacitance against temperature

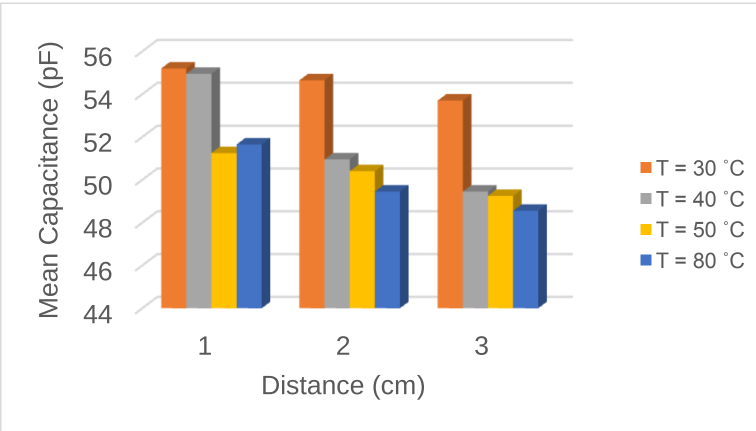

Fig. 2. Mean capacitance against distance

For a capacitor through which electricity is passed, heat is generated and the heating effect is proportional to the duration, current and voltage passing.

4. CONCLUSION

The temperature and distance effects are significant to this physical property but the rise in temperature does not result in damage or major dielectric property loss. Thus, this result shows the viability of SB as a potential dielectric liquid to prospect. The lubrication effect of SB combined with its physicochemical properties can be improved with the addition surfactant if it is to be used as transformer oil. The chemical composition of SB must have aided the potential capacitance which must be needed in its applications. This charged electrons stored also contribute to the medicinal use of SB, acting as antioxidants similar to those gotten from food and the earth by walking barefoot [19,20].

COMPETING INTERESTS

Authors have declared that, no competing interests exist.

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