

**THE EFFECT OF FREQUENCY VARIATION ON
DIELECTRIC CONSTANT OF RAPHIA HOOKERI
(PENGARUH VARIASI FREKUENSI KONSTANTA DIELEKTRIK PADA
RAPHIA HOOKERI)**

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ABSTRACT

This work sought to investigate the effect of varying the frequency of an applied electric field on the dielectric constant of raphia hookeri. The aim of the work was to ascertain the suitability of using the sample for engineering applications. It was revealed, from the recorded results, that the dielectric constant of the sample decays exponentially with frequency. Also, greater degree of polarisation was observed with decrease in frequency. Again, as a good thermal insulator, it was revealed that the values of the sample's dielectric constant compared favourably with those of commonly used conventional dielectric materials. Thus, it is obvious that if put into production cycle, the sample can serve as a low-cost and environmental friendly material suitable for engineering applications within audio frequency range. This will, in turn, help to provide raw material for electronic industry and also improve the economy.

Keywords : Dielectric constant, Frequency variation, Raphia hookeri

ABSTRAK

Penelitian ini dilakukan untuk menyelidiki pengaruh variasi frekuensi pada medan listrik menggunakan konstanta dielektrik pada raphia hookeri. Sasaran dari penelitian adalah untuk memastikan kesesuaian menggunakan sampel untuk aplikasi teknik. Didapati dari hasil yang tercatat bahwa konstanta dielektrik sampel meluruh secara eksponensial dengan frekuensi. Juga, tingkat polarisasi yang lebih diamati dengan penurunan frekuensi. Lagi, sebagai isolator suhu yang baik, didapati bahwa nilai konstanta dielektrik sampel mempunyai perbandingan yang baik dengan bahan dielektrik yang umum digunakan. Dengan demikian, jelas jika dimasukkan ke dalam siklus produksi, sampel dapat digunakan sebagai bahan yang murah dan ramah lingkungan yang sesuai untuk aplikasi bidang Teknik yang melibatkan rentang frekuensi audio. Ini tentunya akan membantu menyediakan bahan mentah untuk industri elektronik dan juga meningkatkan ekonomi.

Kata kunci : Konstanta dielektrik, Raphia hookeri, Variasi frekuensi

INTRODUCTION

Raphia Palm is a monocotyledonous evergreen plant that is cultivated for many purposes. In the history of mankind, this plant has played a

significant role and according to (Aluasa et al., 2011), it belongs to the family called *palmaceae*. When cultivated in swampy or semi-swampy areas, a typical full-grown

raphia palm can be taller than 15m especially in Southern part of Nigeria. By nature, raphia palm produces flowers and then dies after a period of vegetative growth (Obuhiagham, 2009).

Raphia palm happens to be a very economic plant as all its parts are useful. For instance, the midrib of its leaflet can be used for broom making while its leaves, bamboo, stem and trunk can be used for the construction of local thatch houses, local wooden bridges and kidder (Oduah, and Ohiman, 2005). As posited by (Udofia, and Oworen, 2017), the petiole of raphia palm leaf yields fibrous *pissava* which are used for weaving as well as production of traditional textile and various kinds of rope suitable for climbing and tying. In addition, raphia palm has been reported to have certain nutritional and health benefits. For example, the sap from it called palm wine contains vitamins, protein and some minerals and is drunk as beverages. Though (Ohimain, 2012) averred in their research work that this sap can be fermented and then distilled into alcohol, (Van Andel et al., 2012) noted that it can be used for treatment of measles, malaria and jaundice fontanel in babies. Equally reported is the use of extract from raphia palm leaves to inhibit carbohydrate utilizing enzymes and this is significant in reducing blood glucose level (Ogunsuyi et al., 2017).

It has been observed that among the useful parts of raphia palm, the leaves are the least utilized by man. As such, when the plant is to be used for other purposes, the leaves are usually discarded and then burnt as waste. Obviously, this practice leads

to environmental pollution with the potential of posing risk to human health. This work, therefore, aims at investigating the component of raphia palm leaves called *hookeri* in order to ascertain its suitability for engineering applications. Specifically, the effect of frequency variation on the dielectric constant of the *hookeri* will be determined and then compared with the dielectric constant of conventional dielectric material used in fabricating capacitors. It is hoped that the findings from this work will help researchers and manufacturers/ users of dielectric materials in their decision-making process.

MATERIALS AND METHOD

Fresh leaves of raphia palm grown in Uyo Local Government Area of Akwa Ibom State were plucked and washed with clean water after which the *raphia hookeri* was extracted from them. The *hookeri* was then allowed to dry at room temperature without twisting before it was covered with a cellophane material prior to its use. This was necessary in order to prevent it from having contact with dust. Two equal plates of copper material were cut and used to form a parallel-plate capacitor with the *hookeri* as dielectric. Care was taken to ensure that the plates overlapped properly and the entire assembly was uniformly weighed down with a load of 20N, such that air gap and the possibility of by-passing the *hookeri* by linking the plates were completely prevented. Measurement of the thickness of the dielectric (*raphia hookeri*) was carried out using digital micrometer screw gauge. With the aid of Schering Bridge circuit

arrangement as described by (Menkiti et al., 2010), the capacitance values for different thicknesses of the *hookeri* were determined at various frequencies of the digital function generator (Model MFG-8215). This measurement per thickness was carried out in triplicates at room temperature after which the mean capacitance values were computed and tabulated. A pair of digital vernier callipers was used to measure the plates dimensions used in calculating their common area according to the relation

$$A=L \times B \quad (1)$$

where L represents the length of the plates/dielectric, B represents the breadth of the plates/dielectric, and A is the common area of the plates. Also, from the plots of mean capacitance values against the inverse of the dielectric thickness, the dielectric constant of the *raphia hookeri* per frequency was deduced based on the equation

$$C_x = \epsilon_r \left(\frac{A}{d} \right) 8.85 \times 10^{-12} Fm^{-1} \quad (2)$$

where C_x is the mean capacitance value per frequency, d is the thickness of the *raphia hookeri* and ϵ_r is the dielectric constant of the *raphia hookeri*.

RESULTS AND DISCUSSION

The results of mean measured capacitance values for various

thicknesses of the test sample (*raphia hookeri*) at various frequencies are presented in Table 1. Also, the computed values of dielectric constant obtained from the plot of mean measured capacitance values against the inverse of the sample's thickness are registered in Table 2. From Table 1, it can be seen that as the frequency of the applied electric field increases, the mean capacitance values of the sample decrease. Similarly, there is an observed inverse relationship between the capacitance values recorded per frequency and the thickness of the sample used. This suggests that the charges that are accumulated increase as the distance between the opposite surfaces of the sample decreases.

Based on the recorded values, it can be observed that increase in the sample's thickness from 0.04mm to 0.12mm results in decrease in capacitance by a mean percentage of $(66.145 \pm 2.153)\%$. Also, as a result of varying the frequency of the applied electric field between 1kHz and 5000kHz, the measured capacitance values decrease by about $(86.096 \pm 1.802)\%$. This portrays the fact that the influence on the capacitance is greater in case of frequency than when the sample's thickness is varied.

Table 1 Results of mean measured capacitance values for various thicknesses

d (10 ⁻³ m)	1/d (10 ³ m ⁻¹)	Mean capacitance values, C_x (in pF) at various frequencies, f (kHz)									
		1.0 kHz	5.0 kHz	10.0 kHz	20.0 kHz	50.0 kHz	100. 0 kHz	200. 0 kHz	500. 0 kHz	1000. 0 kHz	5000. 0 kHz
0.0 4	25.00 0	224. 2	202. 1	156. 6	127. 9	101. 6	80.9	71.5	51.4	45.1	44.2
0.0 6	16.66 7	221. 2	134. 8	104. 4	85.3	67.7	54.0	47.7	34.3	30.1	29.5
0.0 8	12.50 0	158. 4	101. 1	78.3	63.9	50.8	40.5	35.8	25.7	22.6	22.1
0.1 0	10.00 0	126. 7	80.9	62.6	51.2	40.6	32.4	28.6	20.6	17.7	13.5
0.1 2	8.333 6	105. 6	67.4	52.2	42.6	33.9	27.0	23.8	17.1	14.7	11.3

Figure 1 illustrates a linear relationship between the mean capacitance values and inverse values of the sample's thickness at each frequency. This is possible since the said capacitance values are in inverse trend with the thickness values of the sample as earlier stated based on the results presented. It can be inferred from the plot that when a fixed

potential difference is applied at a particular frequency across the sample through plates of common area, the magnitude of charges on either of the plates decreases with increase in the sample's thickness. This results in an increasing tendency of the sample to inhibit the flow of current.

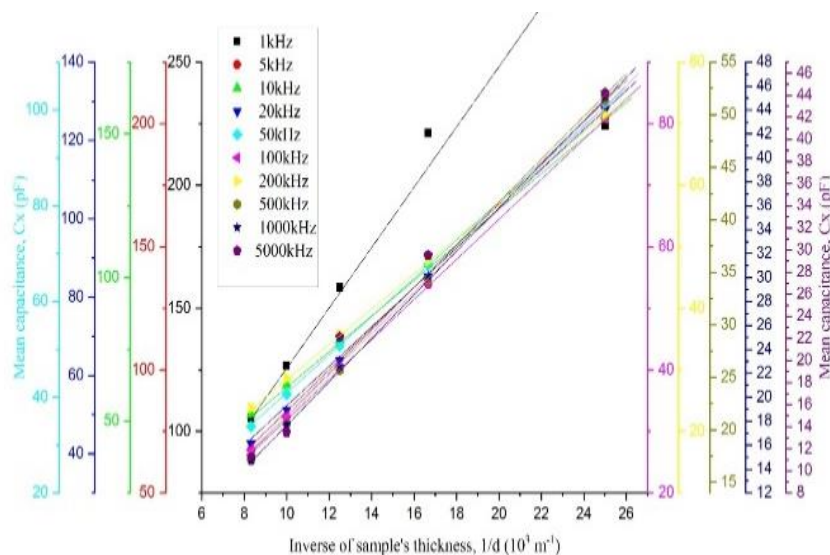


Figure 1 Plot of mean capacitance values against inverse values of the sample's thickness

Table 2 Dielectric constant values of the sample (*raphia hookeri*) at various frequencies

Dielectric constant, ϵ_r	Frequency, f (kHz)
9.214	1.0
6.821	5.0
5.284	10.0
4.316	20.0
3.428	50.0
2.731	100.0
2.413	200.0
1.735	500.0
1.518	1000.0
1.443	5000.0

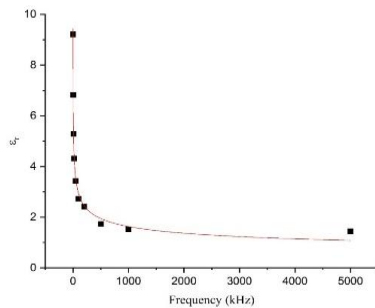


Figure 2 Plot of dielectric constant as a function of frequency.

Table 2 shows the variation of dielectric constant of the sample with frequency. It can be observed from it that the values of the dielectric constant depend inversely on frequency. As can be deciphered from figure 2, the relationship between the dielectric constant values and the frequency values is an exponential decay. A seeming stability in the value tends to occur from frequency value greater than 1000 kHz. This means that if placed in an electric field, as the ability of the sample to store electric charge decays with increase in applied frequency, no significant decrease in the dielectric constant is possible at extremely high frequency. Above all, the hygroscopicity of the sample is seen to play a vital role for the variation of

its dielectric properties. Also, greater degree of polarisation is possible as the frequency values decrease.

CONCLUSION

The dielectric constant of the test sample (*raphia hookeri*) was observed to decay exponentially with the frequency of an external electric field applied. Within the audio frequency range (1.0 kHz to 20 kHz), the values of dielectric constant recorded in this work cut across the literature values for conventional dielectric materials such as polystyrene (2.6), waxed paper (3-5), mica (3-6), glass (7-8), and bakelite (4.5-5.5) (Shedha, 2008). Also, with the reported thermal resistivity of $17.730 \text{ W}^{-1}\text{mK}$ [1], it is obvious that apart from being a good thermal insulator, the test sample can be used as a low-cost and environmentally friendly dielectric material for engineering applications within audio frequency range.

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