Orange peel an Excellent high k material

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Abstract

The present work deals with dielectric study of agriculture waste by using LCR meter. The agriculture waste is collected from agriculture and fruit market. Biowastes samples orange peel was characterized by using XRD and FTIR techniques. The dielectric material is in the pellets form are prepared by KBr making die set. The dielectric parameter such as dielectric constant, dissipation factor and Ac conductivity of all samples are studied in the frequency range 10Hz to 2MHz**.** Similarly impedance plot of all the orange peel samples is studied. The dielectric constant of all the sample decreases as frequency of applied ac field. The orange peel sample has dielectric constant found to be 60 and considered as high k materials.

1. Introduction

The dielectric material is consider as an electrical insulator, but it may be polarized by an external electric field. The dielectric material can cause dielectric polarization due to the placed in external electric field[1]. It have high demand in the market due to its ability to store of energy. It exhibits high dielectric strength with low power loss, stable dielectric constant and high electrical resistance in electrical applications [2]. Broadlly dielectric materials are categorized into two ways i.e high k and low k materials[3] The high k dielectric material whose k value is conventionally greater than 3.3. The High-k dielectric materials have recently become important mainly in three areas: memory cell dielectrics, gate dielectrics, and passive components [4]. The communication engineering and technology are believed toward portable, high circuit density, and low power electronic microsystems, have demanded the use of low-k dielectrics (k value less than 3.3) as the interlevel dielectric (ILD) material[5]. The traditional dielectric material is a non-renewable material that might be exhausted in upcoming years. Therefore it is need to search for new renewable dielectric material. This search will be focus on bio based materials. The biowaste materials consists of organic materials, including agricultural waste, fruit peel and leaf. By using agricultural and biowaste in engineering applications, the environmental problems caused by the incorrect disposal of these wastes may be reduced. These wastes could be utilized in place of the costly traditional dielectric material because they are easily available. It is anticipated that the ongoing utilization of these wastes will satisfy the growing demand for materials brought about by the exponential rise in human population. The use of economically and nature friendly renewable sources may decrease the use of non-renewable sources. This is ultimately resulting in the material preservation for the next generation. Due to their outstanding qualities, bio-wastes and agricultural waste should be applied more widely in all fields. The potential for alternative and beneficial improvements in agriculture and bio-waste is enormous for a variety of engineering applications. In addition biowaste and agriculture waste materials are utilized as microwave signal absorbers and as a replacement for the antenna and conventional printed board applications. Biological and agricultural residues are organic compounds made up of renewable sources such as rice husks, wheat straw, cucumber peel, sugar cane bagasse, banana peel and stem. There are several advantages of using agricultural waste to produce dielectric materials. Besides being environmentally and economically friendly, agricultural waste is a renewable source of elements and a better way of managing many agricultural wastes for producing various engineering materials.

Orange peel(OP) is one of the agricultural wastes from the orange juicing industry. It is abundant, cheap, readily available and made up of cellulose, pectin, hemicellulose, lignin, chlorophyll pigments and other low molecular weight compounds, including limonene[8]. These wastes create increasing disposal and environmental problems. The modified OP used for metal ions removal from simulated wastewater[9]. It is used as precursor material for the generation of an adsorbent by chemical treatment. In the present manuscript, orange peel is elected and its dielectric study is carried out.

2. Methods and Materials-

2.1 Preparation of dielectric sample

Orange peel is collected from agriculture. It is washed with distilled water for removing impurity and dried in air atmosphere under the sun light. The OP is crushed by using agate mortar into small fine size powder. This fine powder is sieved through sieve and used for further without purification

2.2 Preparation of pellets

For dielectric measurements, the OP powder is converted into pellet by using KBr making die set[11]. The sample is forced at 5 tons of pressure to create a compact pellet with 13 mm diameter and 2 mm thickness. The flat surface of pellets are coated with silver paste for proper electric contacts. The pellets are used as a dielectric sample for further dielectric study.

2.3 Characterization

Op is characterized by XRD, FTIR and TGA. The XRD peaks are obtained with a X-ray diffractometer with CuKα radiation. The range of diffracted angle 2θ is kept from 20° to 60° for XRD study. FTIR spectrophotometer made by Shimadzu is used to detect the functional groups in the samples with a resolution of 4 cm^{-1} and average of 40 scans from 4000 cm^{-1} to 400 cm^{-1}.

2.4 Dielectric Measurements

The capacitances (Cp), real and imaginary parts of impedance are calculated with a parallel-plate capacitor arrangement using QuadTech 7600 LCR meter. The measurements are carried out at room temperature, in the frequency range 10 Hz–2MHz[12]. Dielectric constants (k) are calculated by using the formula:

$$k = \frac{C_p}{\varepsilon_0} \times \frac{t}{A}$$

where k is dielectric constant, C_p is the capacitance of the sample, t is the thickness of the sample, ε_o is the permittivity of the vacuum and A is the area of cross-section of the sample pellet. AC conductivity is calculated using real and imaginary parts of complex impedance with the aid of following formula:

$$\sigma = \frac{(Z')^2}{(Z')^2 + (Z'')^2} \times \frac{t}{A}$$

where Z′ and Z″ are the real and imaginary parts of the impedance, A is the area of sample and t is the thickness of the sample.

3.Result and discussion

3.1 XRD Analysis

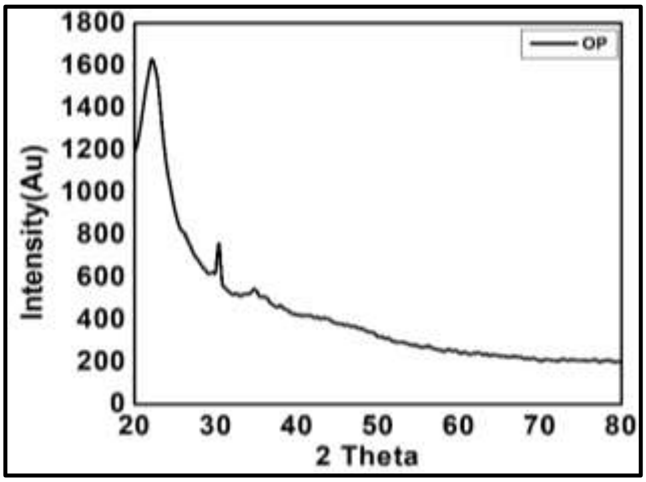

Fig 1. XRD profiles showing typical peaks of orange peel

Fig I(a-e) shows the change of intensity of diffracted X-rays as a function of 2θ value in the range of 5°-60° for biowaste sample Orange peel. The single diffraction peak is observed at 22 ^{o} with lattice constant (101). The one broad peaks shows amorphous nature of Op[13].

3.2 FTIR analysis

The FTIR spectra of orange peel are observed in fig 2. The bands are obtained at 3351cm^{-1}, 2925 cm^{-1},1734cm^{-1},1436cm^{-1}, and 1042$cm^{-1}$are found due to O-H Stretching, C-H stretching vibrations of methyl, methylene and methoxy groups, stretching vibration of C=O of pectin, hemicellulose and lignin, aliphatic and aromatic C-H groups in the plane deformation vibrations of methyl, methylene and methoxy group and C=O stretching vibration of carboxylic acids and alcohols respectively[13].

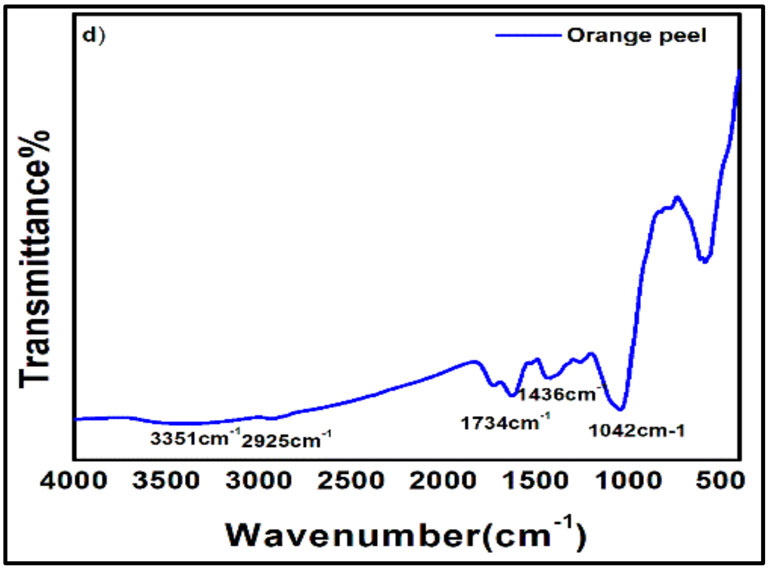

Fig 2. FTIR spectra of OP materials showing functional group present in the samples

3.3 Dielectric analysis

3.3.1 Dielectric permittivity

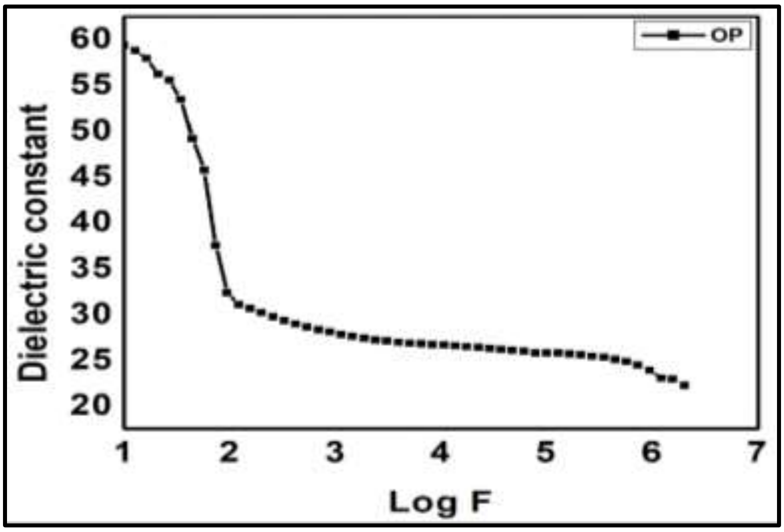

Fig 3. Variation of dielectric permittivity of Op with function of applied frequency of ac field

Fig 3 shows the change in dielectric constant of Op as a function of applied frequency of ac field at room temperature. It is showed that of dielectric constant of Op sample dependant on frequency and can be divided into two regions: a low frequency region (10 Hz to 1 kHz) and high frequency region (above 1KHz). In low frequency region, dielectric constant decreases rapidly as frequency of applied field increase upto 1 KHz. It indicates that strong dependence of dielctric constant in low frequency region due to the dispersion in the material[14]. The dipolar relaxation in the material is responsible for decrease in dielectric constant in frequency range 10Hz to 1KHz. The dielctric constant remains constant in high frequency region i.e above 1KHz. It is named as plateau region wherein dielectric constant of Op shows frequency independent behaviour. It is proved that dielectric constant is a frequency dependent parameter for orange peel. The value of dielectric constant of orange peel is calculated at frequency 10Hz is 60

b) Dissipation factor

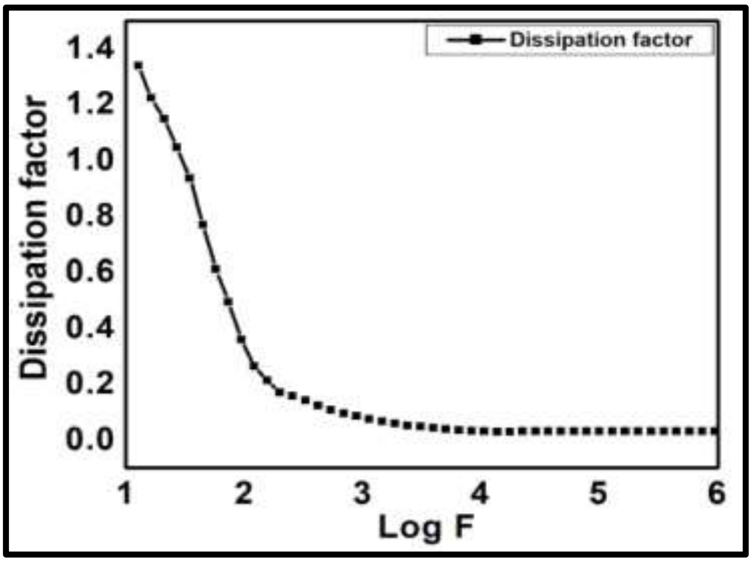

Fig 4. Change of dissipation factor of Op sample with function of frequency of applied ac field.

Fig 4 depicts the variation of the dissipation factor with applied frequency of a.c field. Actually it measures the absorption and loss of electrical energy. It shows the inability of material to store energy or loss of the energy due to the applied a.c field. The majority energy is lost in the form of heat. The curve of dissipation factor vs frequency of ac field decreases as the frequency of the ac field increases[15]. It becomes constant in between low frequency and high frequency region. At the end, the value of dissipation factor slightly increases.

d) AC conductivity

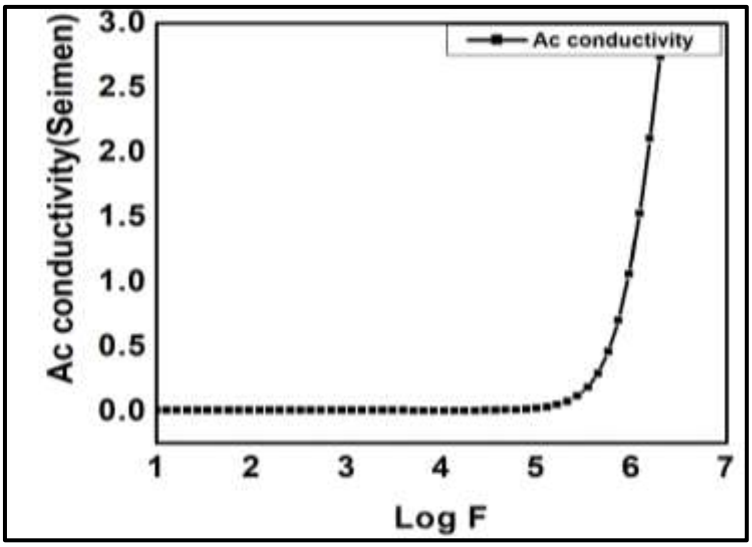

Fig 5. Variation of ac conductivity with function of frequency of ac field

Fig 5 shows the variation of ac conductivity with frequency of applied Ac field. Ac conductivity of each sample is independent upto 10^5 Hz and after that it shows upward bending of plateau region at about 10^5 Hz in almost all samples. In high frequency region i.e in the hopping region, ac conductivity strictly follows the universal power law and deviates from plateau region. This deviation of ac conductivity in high frequency region is due to the hopping phenomenon[16,17,18]. The ac conductivity of samples at higher frequency.

4. Conclusion

The agricultural waste Op exhibits very good dielectric properties. The dielectric constant of Op is found to be around 60, indicating its strong ability to store electrical energy. The dissipation factor is observed to be low, confirming its minimal energy loss during polarization. Additionally, the AC conductivity of Op increases in the higher frequency region. Overall, Op shows significant potential to be considered as a high-k dielectric material.

5. Acknowledgement

Author would like to acknowledge the honorable vice chancellor of Swami Raman and Teerth Marathwada University, Nanded for it’s constant support and encouragement throughout study.

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