International Journal of Research in Advent Technology, Vol.6, No.2, February 2018
E-ISSN: 2321-9637
Available online at www.ijrat.org

Studies on Dielectric Properties of Cow dung/glass fiber reinforced with polyester hybrid composites

T.Ranjeth Kumar Reddy[1], T.Subbarao[2], R.Padmasuvarna[3], P. Sreenivasula Reddy[4]
[1]Department of Physics, Holy Mary Institute Of Technology and Science, Hyderabad, Telangana, India
[2]Department of Physics, Sri Krishnadevaraya University, Anantapur, Andhra Pradesh, India
3Department of Physics, JNTU Engineering College, Anantapur, Andhra Pradesh, India
4Department of Physics, Sri Venkateswara Engineering College, Kadapa, Andhra Pradesh, India
Email: ranjithreddy155@gmail.com[1]

Abstract- In this Present research work deals with the synthesis and characterization of raw and surface modified cow dung fibers and a constant glass fiber mat reinforced unsaturated polyester (UPE). Raw and surface modified fibers have been used in different proportions for the preparation of these composites. Dielectric constant, Dielectric loss, and dissipation factor were observed by applying frequency range from 1 kHz – 5 MHz at constant room temperature. It was identified these dielectric properties were higher in untreated composites compare with treated composites. FTIR and SEM analysis of fiber characterization gives a support above result.

Index Terms- Glass fibers; Hybrid; Electrical properties; Lay-up (manual/automated); Thermoplastic resin.

1. INTRODUCTION

In recent years, composites reinforced with fillers and cellulose fibers have greatest importance in this current arena due to the threats of uncertain petroleum supply and concerns about environmental pollution. Natural fiber reinforced polymer composites have superior properties like high strength, toughness, low cost, and biodegradable. By comparing with synthetic fibers these natural fibers exhibit low properties. The main drawback in the natural fibers is their hydrophilic nature which causes the poor interfacial adhesion between matrix and fiber. But the synthetic fibers are moisture repellence due this composite reinforced with synthetic fiber show better properties [1-3].

On the other hand some other reported the hydrophilic nature of natural fibers reduced by chemical treatment of fibers by different methods. Many researchers used different methods in the processing composite. silane, titanate and zirconate coupling agents used as chemical reagents used for treatment of natural fibers, this results increasing in mechanical properties of sisal/ polyester composites. It was observed that this treated fibers shown improved acid–base characteristics and resistance to moisture. Composites produced from these treated fibers showed slightly better mechanical properties [4-6].

Many of them reported possible to usage of these composites in various types of applications, but from the last two decades researches had focused on dielectric applications of the natural fibers reinforced composites. The natural fiber reinforced composite materials have been used as dielectric materials in microchips, parts of transformers, terminal, connectors, switches, circuit boards, etc. Therefore, studies of dielectric properties of natural fibers reinforced composites materials are very important. The dielectric strength and volume resistivity of the natural fibers reinforced composites have been observed by various observers [7-8]. Pothan et al. [9] have observed that the electrical and mechanical properties of banana fiber reinforced polyester composites. In this study it was identified the dielectric constant values decreases by making the chemical treatment of natural fibers. Dielectric constant values of resulted composites decrease. Some other observed increase in conductivity with reinforced sisal and natural rubber [10]. It was observed the dielectric properties of banana fiber reinforced with phenol formaldehyde composites have been also studied with respect to fiber loading, fiber treatment and hybridization with glass fibers [11]. With the surface modifications of fibers observed decrease in dielectric properties of the composite.

In this present work, the effect of fiber loading and chemical treatment was identified on dielectric properties of treated and untreated composite has been investigated. Unsaturated polyester resins were chosen for making fiber rein-forced plastics (FRPs) because of their easy handling and fabrication, good strength and low cost in comparison to epoxy or phenolic resins.

2. METHODOLOGY

2. Materials

Cow dung obtained from local sources and some of these fibers were soaked in 5% NaOH solution for 30 min. To remove any fatty material and hemi cellulose, washed thoroughly in distilled water and dried under the sun for one day. The glass chopped stand mat was used in making the hybrid composite percentage. The unsaturated polyester resin obtained from Sree Composites World.ltd, Secunderabad, A.P, India, Methyl Ethyl Ketone Peroxide as accelerator and Cobalt Naphthenate as catalyst, which are obtained from M/S Bakelite Hylam Hyderabad, A.P, India, were used.

2.2 Preparation of the Composite and Test Specimen

In this present work hand layup technique was used for preparation of composite. Later the unsaturated polyester matrix and styrene monomer was mixed thoroughly in the ratio of 100:25parts. Then cow dung added randomly with constant glass fiber in the matrix. For making hard of the composite added 1%of Methyle Ethyle Ketone Peroxide (MEKP) as accelerator and 1% of cobalt naphtahanate as catalyst and mixed carefully. Later entire glass mould was coated with mould releasing agent of silicon and the mixture of the matrix poured in to the glass mould. By applying the pressure on the top of the casting then the excess of resin was removed from the glass mould. Now this glass mould is placed at the room temperature by 24 hrs then it is placed in a woven at the temperature of 70^oC for 3 hrs. The composite were released from mould and are cut to prepare test specimens.

3. RESULTS AND DISCUSSIONS

3.1. Fibers characterization

FT-IR spectra of raw and surface modified Cow dung fibers were taken with KBr pellets on PERKIN ELMER RXI Fourier Transform Infrared Spectrophotometer. FT-IR spectrum (Fig. 1) of raw cow dung fibers showed a broad peak at 696.16 cm_1 (due to out of plane -OH bending), 873.31 cm^{-1} (due to b-glyco-sidic linkage), 1255.46 cm^{-1} (due to –C-O-C- and –C=O stretching in xylan side substituent and lignin aromatic C=O stretching), milder peaks at 1376.2–1491.73 cm^{-1} (due to -CH, -CH2 and -CH3 bending), 1718.50 cm^{-1} (due to H-O-H bending of absorbed water and for lignin C-H deformation), 2001.54 cm^{-1} (due to O-H stretching of absorbed moisture), 2494.96 cm^{-1} (due to C-H stretching in polysaccharide chains), 2914.78 cm^{-1} (for C-H stretching vibration of aliphatic methylene group) and an intense broad peak ranging from 3094.20 to 3629.56 cm^{-1} (due to the hydrogen bonded -OH vibration of the cellulose structure fiber).However on treatment of Lignocellulosic fibers with dilute NaOH solution strong bands at 1629.68 and 1259.54 cm_1 have been found to disappear due to removal of substational portion of uranic acid, lignin, adhesive pectins and hemicelluloses. The peak at 1629.68 is assigned to carbonyl group of pectins it is shown from Fig 2.

From FT-IR spectra it has been observed that the intensity of adsorption band at 3395.9 cm_1 (due to -OH group) decreases after the fibers surface modification, which supports the development of hydrophobic character onto natural fibers.

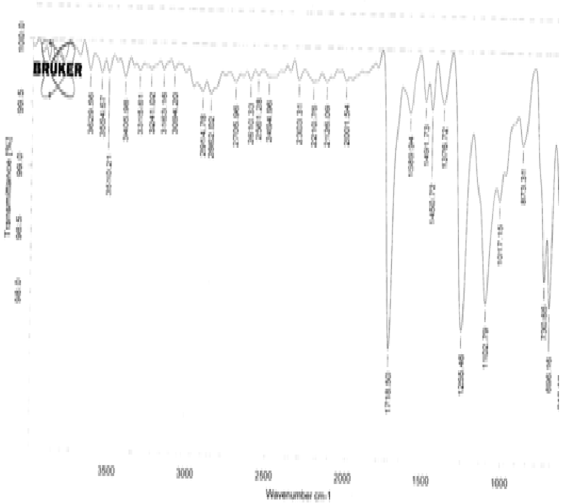

Fig 1.Raw fiber

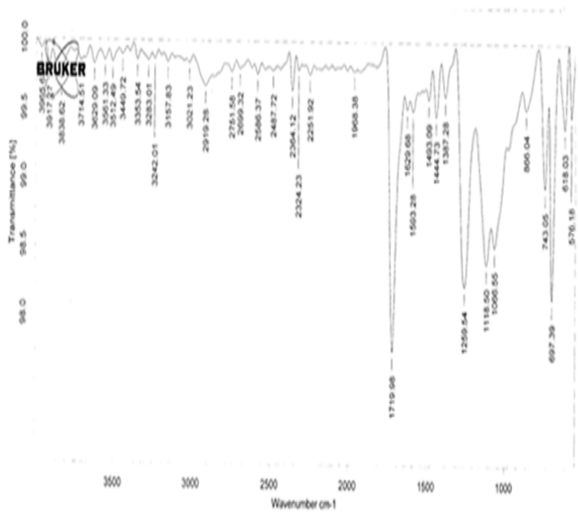

Fig 2. Surface modified fiber

3.2. Dielectric Properties

3.2.1. Dielectric constant, loss and dissipation factor

Dielectric constant is defined as ratio of capacitance of a capacitor in consisting as dielectric to the capacitance of a capacitor in vacuum i.e. without any dielectric. It is also called relative permittivity and is denoted by symbol (ε_r). This Dielectric constant provides the information about its dielectric strength of an insulation material. This parameter helps in selection of dielectric capacitor material for the purpose of designing and manufacturing appropriate value of capacitor to be used in capacitor banks for electrical power factor improvement of an electric system installation as it facilitates reduction of energy losses in transmission lines. If a material having high relative permittivity is placed in an electric field, then magnitude of that field will be reduced within volume of the dielectric. This fact is used commonly by various researchers to design capacitance of suitable value. The dielectric constant ε_r of specimens can be calculated from capacitance by using the following equation.

$$\varepsilon_r = Ct / \varepsilon_0 A$$

Where 'ε_r' is relative permittivity, 'C' is capacitance of insulation material,'t' is the thickness of specimen, 'ε_0 is permittivity of free space and 'A' is area of test specimen under electrode. For specific samples, dielectric constant varies in direct proportion with capacitance. Further dissipation factor tanδ, which is a measure of power dissipated, has been calculated from the following equation.

$$tan\delta = \frac{\varepsilon_r{'}}{\varepsilon_r}$$

Where '$\varepsilon_r{'}$' is loss factor and 'ε_r' is dielectric constant.

The prepared samples were cutting them into rectangular specimens of dimensions(10mm×10mm×3mm) using diamond cutter for the purpose of determining dielectric properties of materials. These samples were coated with silver paste on either side and allow to dry in air. After drying copper wires were fixed on both sides of the samples, which acted as formal electrodes. The dielectric properties i.e. dielectric constant, dielectric loss and dissipation factor for all samples were measured at room temperature in the frequency range (1kHz-5MHz) by using an LCR impedance analyzer (Hioki 3532 -50 lcr hitester).

The dielectric constant, loss factor and dissipation factor of optimized samples of glass fiber, Untreated and treated cow dung/glass fiber reinforced UPE composites have been depicted in Figs. 3–5.

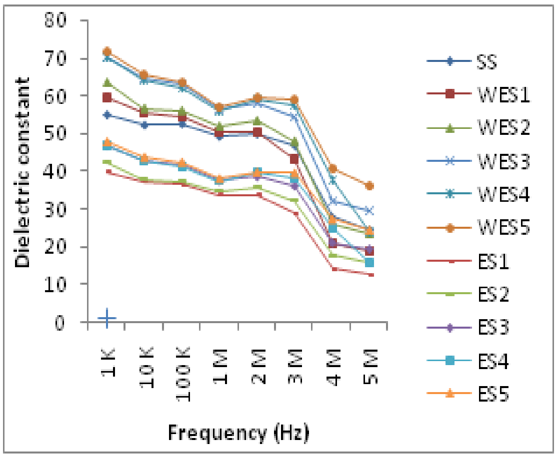

Fig 3.Dielectric constant vs frequency

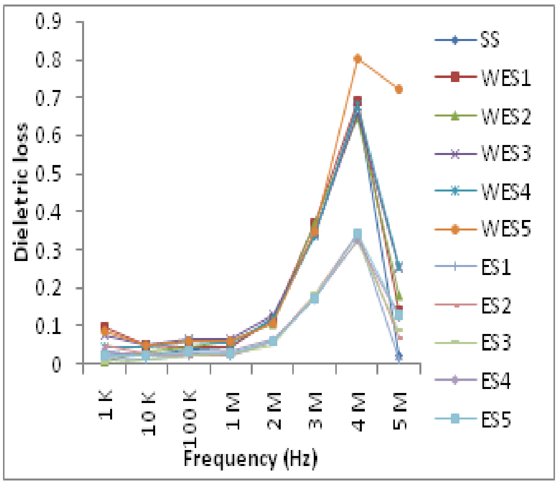

Fig 4. Dielectric loss vs frequency

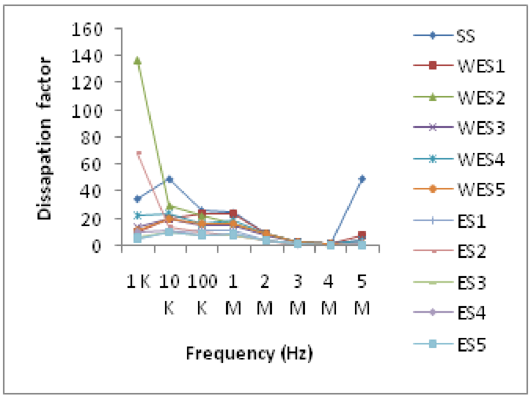

Fig 5. Dissipation factor vs. frequency

It has been observed from Fig. 3 which represents the variation of the dielectric constant of cow dung/glass fiber reinforced polyester as a function of frequency. The dielectric constant increases with increase volume fraction of fiber content [19]. For the composites, ε_r values mainly depend upon the contributions of interfacial, orientation, atomic and electronic polarizations in the material. Due to the differences in conductivities or polarizations of the matrix and filler, the interfacial polarization occurs. This interfacial and orientation polarizations depends upon the concentration of fillers too. Due to presence of polar groups of cellulose in natural fibers, It is also found that for a given fiber loading, the 'ε_r' shows high values at lower frequencies due to the decrease in the orientation polarization with increase in frequency. The complete orientation of the molecules is possible only at lower frequencies and the orientation polarization requires more time to reach the equilibrium static field value compared to electronic and atomic polarizations. Therefore, as frequency increases the 'ε_r'reduces due to the lag in orientation of polarization [18].

The dielectric constant of untreated Cow dung/glass fiber reinforced polyester composites should be higher when compare with glass fiber reinforced polyester. Because of the hydrophilic nature of natural fibers which absorb the moisture content (water molecule) from air and thus causes increased conductivity of the polymer materials [15]. Basically, these water molecules are highly polar in nature which increase surface polarity of composite materials and are generally responsible for such a behavior of raw fiber reinforced UPE composites.

On the other hand, chemical treatments of Cow dung fiber have decreases their dielectric constant compare with raw fiber composite. This is due to decrease in orientation polarization of treated fiber in composites. This result lowers the value of dielectric constant values of finally manufactured eco friendly composites. The effect of chemical treatment on cow dung fibers was it reduces moisture behavior of fibers because of –OH groups in fiber were blocked [12-14]. Thus resultant decrease in hydrophilicity of the polymer composites leads to lowering of orientation polarization and subsequently dielectric constant value [15-16].

From Figs. 4 and 5 it has been observed that dielectric loss and dissipation factor is also affected by chemical treatments fiber. As same as the above discussed dielectric constant, further similar to the result obtained in the study of dielectric loss and dissipation factor. It has been found dielectric loss and dissipation factor should be higher in untreated composites compare with treated composites. It may be due to the incorporation of functional groups of different nature onto lignocellulosic fibers after their surface modification. On the other hand it is difficult to explain dielectric loss or dissipation factor depends upon fiber orientation [17].

3.3. Scanning Electron Microgram Analysis

3.3.1. *Untreated Cow Dung Fiber*

The micrograms of splintered surfaces of untreated cow dung fiber are presented in Fig.6. From this micrograms, it is evident that fiber pullout is observed, indicating a poor bonding between the fibers. Due to hydrophilic nature of natural fiber it absorbs water molecules from moisture. This result there was a poor interfacial bonding between fiber and resin.

3.3.2 *Treated Cow Dung Fiber*

The micrograms of alkali treated cow dung fiber composites are presented in Fig.7. From these micrograms it is clearly evident that the surface of the fibers becomes rough on alkali treatment. The elimination of hemi-cellulose from the surface of the cow dung fiber may be responsible for the roughening of the surface. Here, however the bonding is improved, fiber pullout is reduced. Thus the alkali treatment improved the bonding. It was also analyzed after the NaOH treatment of fiber diameter of the fiber was identified 76 micro meters and diameter of void size calculated with using HSG soft ware and found it could be 18 micro meters it is shown in fig 8& fig.9.

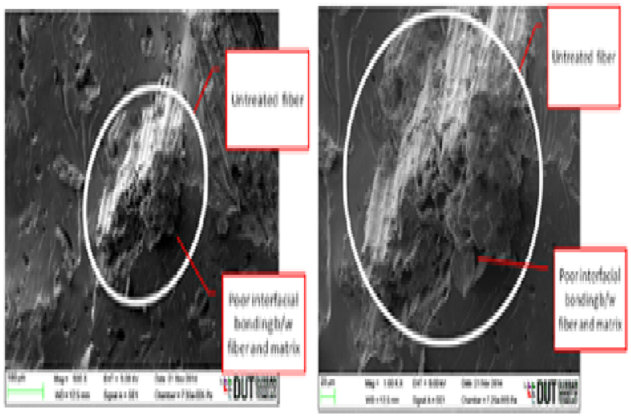

Fig 6. SEM micrograph of fractured surface of untreated cow dung polyester composite

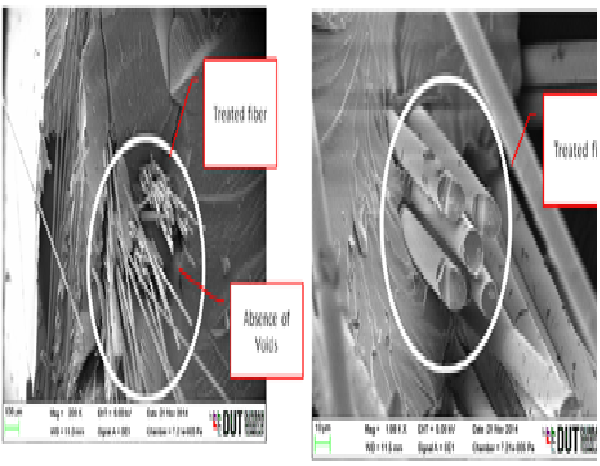

Fig 7.SEM micrograph of fractured surface of treated cow dung polyester

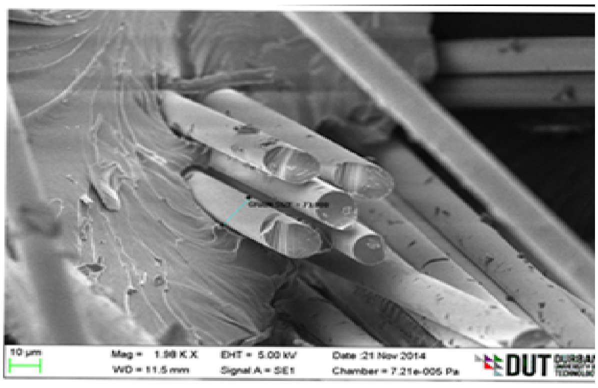

fig 8. Diameter of treated cow dung fiber

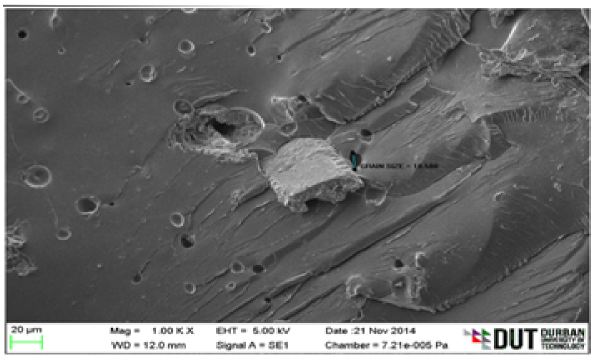

Fig 9. Void size of treated cow dung fiber composite

4. CONCLUSIONS

The dielectric properties of raw and surface modified cow dung fibers and constant glass fiber mat reinforced unsaturated polyester (UPE) composite was observed. Spectacular effect observed Dielectric constant, Dielectric loss, and dissipation factor were changes by applying frequency range from 1 kHz – 5 MHz at constant room temperature. Due to the hydrophobic nature of natural fiber the orientation polarization takes place in composites. It was observed that at low frequency range dielectric properties increases with increasing volume fraction of fiber in both raw and surface modified fibers, but the dielectric properties were higher in untreated composites compare with treated composites. From FT-IR spectra it has been observed that the intensity of adsorption band at 3395.9 cm_1 (due to -OH group) decreases after the fibers surface modification, which supports the development of hydrophobic character onto natural fibers.

REFERENCES

[1] Mohanty AK, Misra M, Drzal LT. Sustainable bio-composite from renewable resources: opportunity and challenges in the green materials world. Polym Environ 2002;10:19–26.

[2] Wang W, Huang G. Characterization and utilization of natural coconut fibers composites. Mater Des 2009;30:2741–4.

[3] Joshi SV, Drzal LT, Mohanty AK, Arora S. Are Natural fiber composites environmentally superior to glass fiber reinforced composites? Compos Part A: Appl Sci Manuf 2004;35:371–6.

[4] Singh B, Gupta M, Varma A. Influence of fiber surface treatment on the properties of sisal-polyester composites. Polym Compos 1996;17:910–8.

[5] Mylsamy K, Rajendran I. Influence of alkali treatment and fiber length on mechanical properties of short agave fiber reinforced epoxy composites. Mater Des 2011;32:4629–40.

[6] Gulatiand D, Sain M. Fungal-modification of natural fibers: a novel method of treating natural fibers for composite reinforcement. J Polym Environ 2006;14:347–52.

[7] Paul A, Joseph K, Sabu T. Effect of surface treatments on the electrical properties of low-density polyethylene composites reinforced with short sisal fibers. Compos Sci Technol 1997;57: 67–79.

[8] Reid JD, Lawrence WH, Buck RP. Dielectric properties of an epoxy resin and its composite I. Moisture effects on dipole relaxation. J Appl Polym Sci 1986;30: 1771–84.

[9] Pothan LA, George CN, Jacob M, Thomas S. Effect of chemical modification on the mechanical and electrical properties of banana fiber polyester composites. Compos Mater

2007;41: 2371–86.

[10] Jacob M, Varughese KT, Thomas S. Dielectric characteristics of sisal–oil palm hybrid biofibre reinforced natural rubber biocomposites. Mater Sci 2006;41:5538–47.

[11] Joseph S, Thomas S. Electrical properties of banana fiber-reinforced phenol formaldehyde composites. J Appl Poly Sci 2008;109:256–63.

[12] Singha AS, Rana AK. Ce(IV) ion-initiated and microwave radiation-induced graft copolymerization of acrylic. Int J Polym Anal Char 2012;17:72–84.

[13] Singha AS, Rana AK. A comparative study on functionalization of cellulose bio-fiber by graft copolymerization of acrylic acid in air and under microwave radiation. BioResources 2012;7:2019–37.

[14] Kulkarni AG, Satyanarayana KG, Rohatgi PK. Electrical resistivity and dielectric strength of some plant fibers. J Mater Sci 1981;16:1719–26.

[15] Andrzej KB, Marta L, Abdullah A, Janusz M. Biological and electrical resistance of acetylated flax fiber reinforced polypropylene composites. BioResources 2009;4:111–26.

[16] Pothan LA, Simon F, Spange S, Thomas S. XPS studies and chemically modified banana fibers. Biomacromol 2006;13:892–8.

[17] Chand N, Jain D. Effect of sisal fibre orientation on electrical properties of sisal fibre reinforced epoxy composites. Composites Part A 2005;36: 594–602.

[18] Birley AW, Hayworth B, Batchelor J. Physics of plastics processing, properties and materials engineering. New York: Hanser Publishers; 1992

[19] Wu SL, Tung IC. Dielectric studies of mineral-filled epoxy. Polym Compos 1995; 16(3):233–9.