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Dielectric Properties of Polymer Matrix/Egg Shells Filler Composite

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ABSTRACT

Composites of PVC (Cement) filled with Egg shells were investigated for dielectric ,water absorption properties .Egg shell particles which is obtained from the local market (insulator part as a filler) has been used with polymer to produce PVC Cement/ Egg shell composite. The egg shells have been cleaned, ground and sieved to (<75) μm. Filler loadings of (5 to 25) wt% were used in compounding the composites has mix at about 65˚C for a few minutes. The mixture then was casted as a film on Al substrates. The measurements were taken in the frequency range from 100Hz to 50KHz and the temperature range (30 to 90 ^{o}C) . Different dielectric behavior was observed depending on filler type, filler contact, frequency and temperature. The dielectric permittivity (ε') and dielectric loss (ε'') increases with the addition of Egg shells filler , which has been attributed to interfacial polarization. In this paper we observed that dielectric permittivity (ε') and dielectric loss(ε'') increases with the addition of Egg shell filler , which is returned to interfacial polarization. where ε' is nearly stable versus frequency whereas it increases with the temperature rise of the composites. The reason is explained for the greater freedom for movement of the dipole molecular chains within the filler at high temperature. the greater freedom for movement of the dipole molecular chains within the filler at high temperature. AC conductivity ($\sigma_{ac.}$) and Impedance of the composites behaviors as function of frequency and temperature have been investigated. The results show that, the real permittivity, dielectric loss and loss tangent for all composites increase the with increasing of Egg shells filler content.

Keywords: Polymer-Matrix Composites, Dielectric Properties, Egg shell.

1. INTRODUCTION

Composite materials have attracted the attention of numerous researchers due to the distinct properties. It well-know that the Utilization of Composite materials in building, structures and many instruments .Since, they were found to have wider applications in fields of automobile, aerospace, marine and house hold [1]. A Composite material is the mixing of two or more of material with different physical or chemical properties. when formed, produce a materials with various properties than the individual components. The initial components remain separate and distinct with in the final structure. The new material is useful for several reasons such as the materials may be become stronger , lighter, or less cost compared to traditional materials[2,3]. Add the filler to the polymer matrix has been an accepted method to a chive enhancement of mechanical, thermal and electrical properties. Furthermore, got to new material with improved material properties with cost saving.

The fillers can be classified in two kinds: organic and inorganic fillers. organic natural fillers are more importance than the inorganic fillers because of their low density, low cost and non-abrasiveness, high loading levels, easy recyclability, bio-degradability, and renewable nature [4-6].

In this work , it was used egg shell powder as filler for PVC cement compound. Egg shell is obtained from the local market. PVC cement is adhesive material similar to a welding based in its work , used to join (glue) two pieces of PVC to gather, in much the same way a welding does. so it is referred to as cementing. PVCs cement are used in several application in modern technology, because these characters ,low shrinking, chemical resistance ,relativity ,low dielectric constant and outstanding adhesion[7,8]. PVC cement instituted composite have good insulating properties in voltage engineering, such as PVC cement/Carbon composite which is used for the dielectric application [9].

2. Experimental

2.1 Materials and Sample preparation

Egg shell particles are used in this research to enhance the dielectric properties of poly vinyl chloride. The egg shell is powdered by using ball milling machine. The average egg shell particle size was (<75) μm. A commercial LICHIDE PVC cement 717-21 heavy duty-clear, with Glass transition Temperature ($Tg=75^{o}$), Dielectric Constant ε' =3.19, molecular, from SWAN TRADING (L.L.C). the egg shells powders were added to the PVC cement in different weight ratio

(5%, 10%, 15%, 20% and 25%) wt%, It is suitably mixed at about 65˚C for 10 minutes. The mixture are put in a Petri dish and left in the lab for (48 hours) The initial curing was carried at room temperature, followed by post curing at 50^{o}C for 4 hours. A thick circular sheet of (4cm) diameter and (1mm) thickness was produced.

2.2- Characterization and measurements

The samples capacitance and the loss tangent (tanδ) of blends were measured by Digital RCL bridge type (MEGGER B131), at the frequencies 1kHz. At the frequencies in the range (100Hz -5MHz), RCL bridge type (Programmable automatic RLC meter, FLUKE PM6306) were used to measure the capacitance of the samples.

The relative complex permittivity (ε*) can be expressed as ε*= ε' – iε'', the real part (ε') or relative permittivity and the imaginary part (ε''). Dielectric loss of permittivity can be calculated from the measured capacitance and loss tangent [17, 18]; $\varepsilon' = Cd/\varepsilon_o A$, and, $\varepsilon'' = \varepsilon' \tan\delta$, respectively. Where, d is the separation between the two electrodes, A is the area of the electrodes, ε_o is permittivity of the free space, ($\varepsilon_o = 8.85\times10^{-12}$ F/m). A.C. conductivity ($\sigma_{a.c}$) is calculated according to the relation. $\sigma_{a.c} = \varepsilon_o\,\omega\,\varepsilon''$ where, ω is the angular frequency[15] . The complex impedance (Z*) can be expressed as the relation $Z^* = Z + iZ'$ where, Z and Z' are real and imaginary parts of impedance, respectively. The real part of impedance Z at different frequencies up to 500 kHz was measured by impedance analyzer (HeweltpacardA4800).

3.Results and Discussion

1.3. Permittivity

The variation of , ε' ,as a function of temperature for the cured PVC (cement) / Egg shells composites in figure (1). At temperature range (30-120^{o}C), the permittivity was found to have low and constant values, this attributed to weak orientation of the dipoles with the applied electric field due to the insufficient free volume available to the dipoles to orient freely. The ε' starts to increase exponentially at temperatures above (75)^{o}C, specially at T_g , which is attributed to the increasing in the number of dipoles to orient freely due to increasing in free volume [10,11].

Fig.(2) shows the frequency spectrum of ε′ for PVC (cement) composites of different filler concentrations. At Frequency range between 100Hz and 50kHz for different Egg shells filler content in the room temperature. Shows that there is a slight decrease in real permittivity with increased frequency. The high values of real permittivity in the low-frequency band are due to the effect of the polarization shown in hetero-phase systems (heterogonous phase systems) .These can be attributed to the Maxwell Wagner Sillars (MWS) interfacial polarization

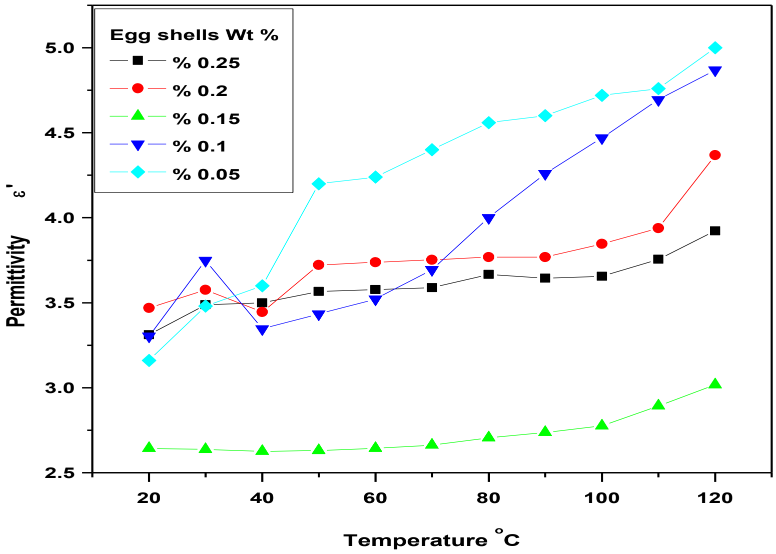

Fig1: The variation of permittivity with temperature for PVC (cement)/Egg shells composites.

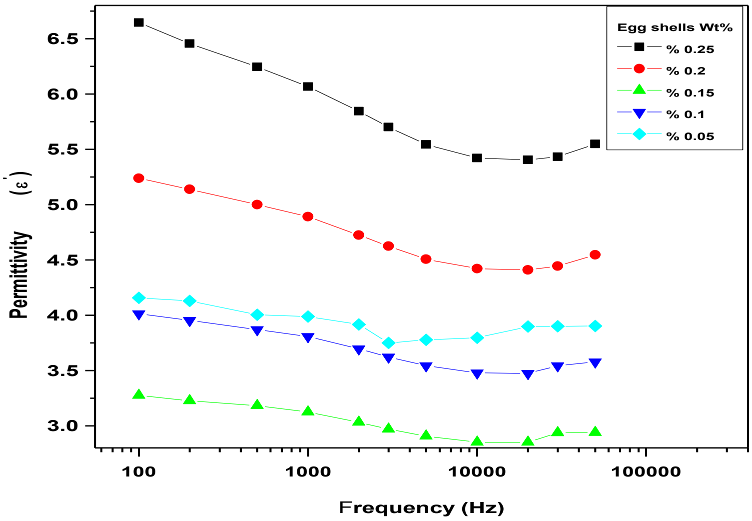

Fig.2: The variation of permittivity with frequency for PVC (cement)/Egg shells composites

3.2-Dielectric loss and a.c conductivity

Figs.(3 and 4) show the variation of (dielectric loss ε") as a function of temperature ,frequency respectively. In Figure(3), temperature in the range (30-120˚C) at a constant frequency (1 kHz) for PVC cement composites. It can be seen that ε" is increased in general as the filler content or temperature increases. The increase in (ε") with increasing of filler contents is regarding to the interfacial polarization, whereas that caused by increasing temperature may be related to the increase of ionic conductivity and segmental mobility. when the rise in temperature (the viscosity will be drop) , We shall note an effect on the amount of losses due to the friction of the rotating dipoles, the degree of dipole orientation increases and ionic conduction increases, due to the thermal dissociation of molecule [11-14].

Fig.(4) show the variation of dielectric loss (ε") of Egg shells filled PVC (cement) composites and unfilled PVC (cement) with frequency. This type of frequency dependence is called dielectric relaxation, which is characterized by a relaxation time(τ), or relaxation frequency (f_o) corresponding to $\Delta\varepsilon/2$. This relaxation shift to low frequencies increases with Egg shells filler content. The values of ε" were high frequencies below 100 Hz, but decreased with frequency up to 50 kHz. It is obvious that the dielectric loss ε'' increases as filler content increases for all frequency rang studied, and ε" shows a maximum for each filler content. These maximum relaxation peaks shift towards lower frequencies as the filler content increases, because relaxation processes were influenced by the interfacial polarization effect. According to the equation $\sigma_{a.c} = \varepsilon_o \omega \varepsilon''$.

The relationship is positive between dielectric loss and a.c conductivity ($\sigma_{a.c}$),so the increases in dielectric loss may be related to a.c conductivity (σa.c) which depends on the number of charge carriers[16, 17]. As shown in Fig(5) ,the observed increase in ac conductivity with temperature is due to the mobility of the charge carriers which is responsible for hopping. As the temperature increases the mobility of hopping ions also increases thereby increasing the conductivity. The electrons which are involved in hopping are responsible for electronic polarization in these composites [18].

AC conductivity as a function of frequency for Egg shells filled PVC (cement) composites is presented in figure (6). It was clear that the ac conductivity increases for all cases in which filler were added. This increase in ac conductivity may linked to the electrical conduction and interfacial polarization [19].

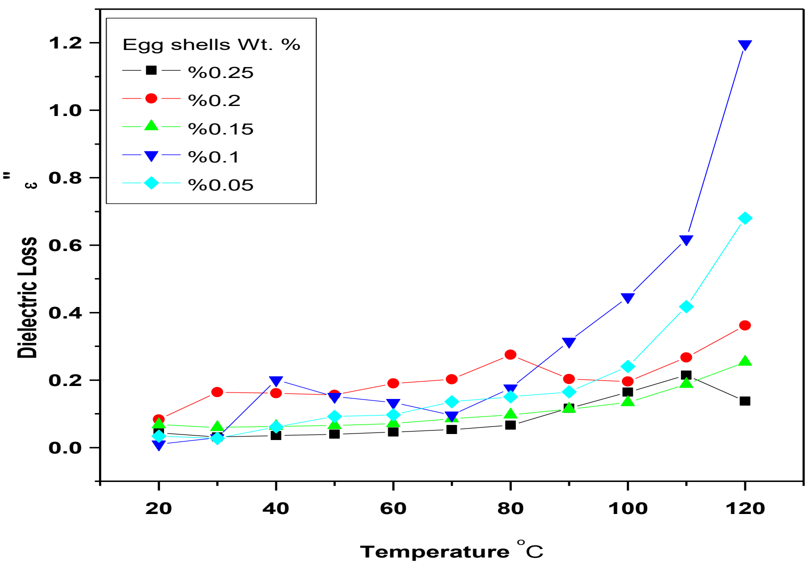

Fig3: The variation of dielectric loss with temperature for PVC (cement)/Egg shells composites

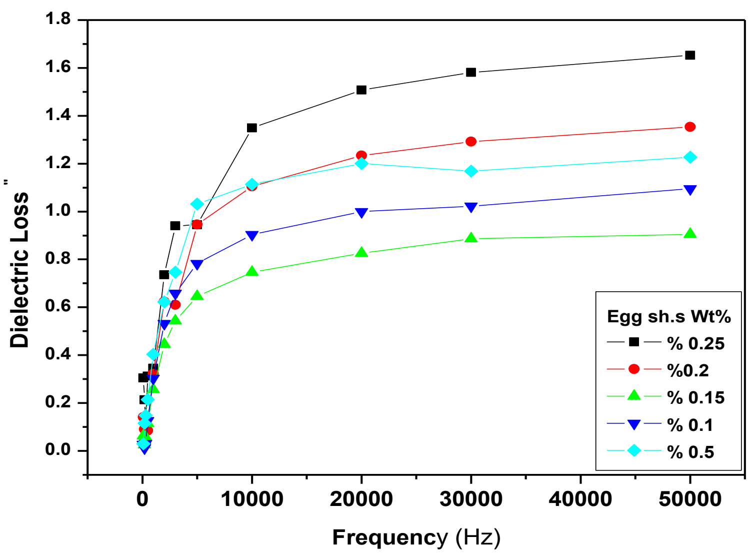

Fig4: The variation of dielectric loss with frequency for PVC (cement)/Egg shells composites

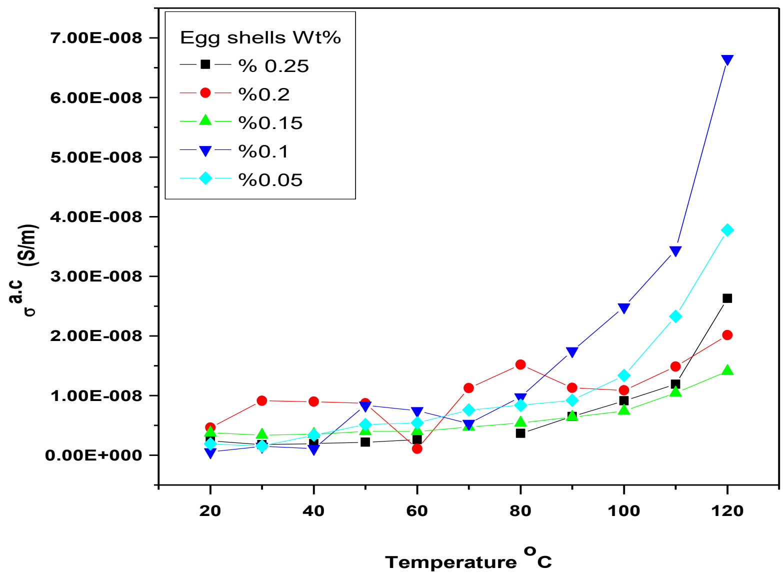

Fig5: The variation of AC conductivity with temperature for PVC (cement)/Egg shells composite

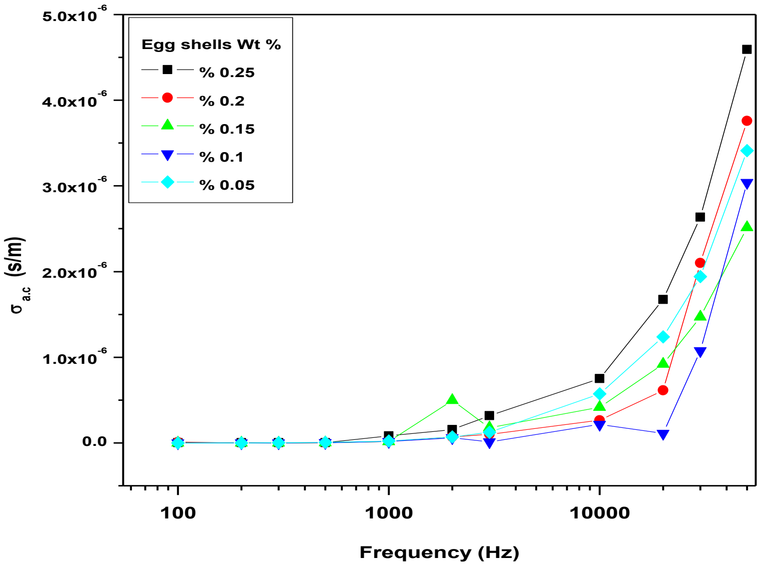

Fig6: The variation of AC conductivity with frequency for PVC (cement)/Egg shells composites.

3.3- Impedance

Fig.(7) appears the impedance Z (real component) with temperature for PVC cement/Egg shells composites (different wt%). There is a marked decrease in impedance with increased filler content due to increased interstitial polarization, and with higher temperature. Fig.(8) Shows the relationship between the impedance (Z) real component and the frequency of PVC cement / Egg shells composites for Egg shells filler content. It was noticed that Inverse relationship between them, i.e when Impedance values decrease with increasing frequency. Decrease in impedance content of Egg shells due to the protonic migration movement impurities present in the filler (Egg shells). This movement leads to high electrical conductivity in the filled composite. When increasing frequency we noticed the exponential decrease in the impedance for all filler Egg shells filler content, and this decrease is major for high filler contents composites.

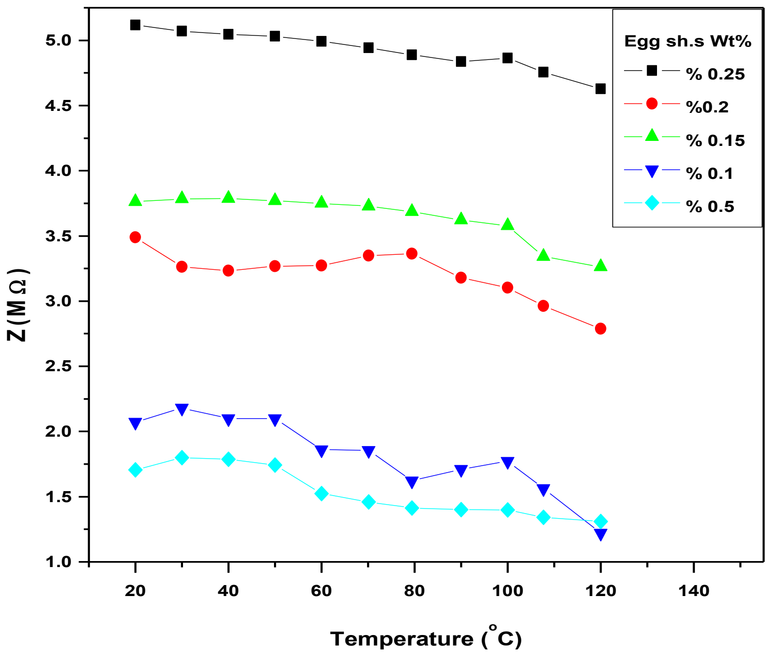

Fig7: The variation of Impedance with temperature for PVC (cement)/Egg shells composites

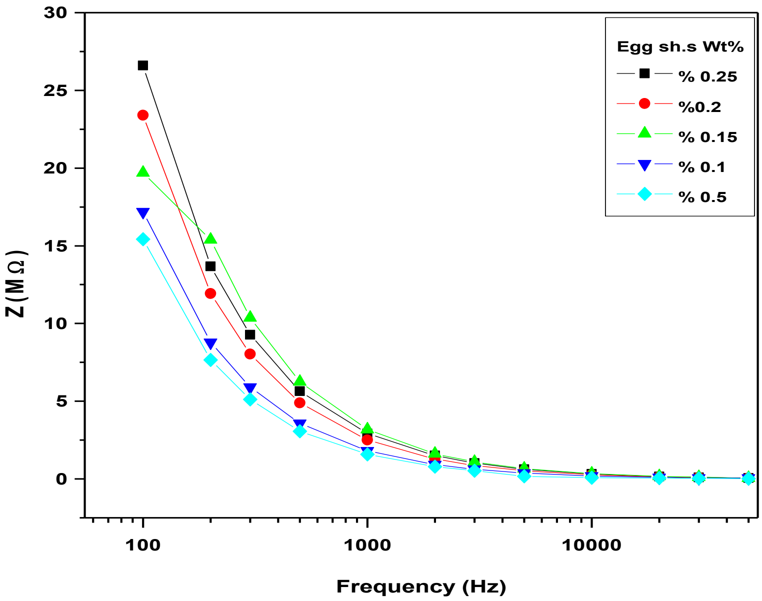

Fig8: The variation of Impedance with frequency for PVC (cement)/Egg shells composites.

4. Conclusion

PVC (cement) Matrix/Egg shell, the dielectric response of composite, in a wide frequency and temperature range , was investigated in the present study. It is found that the permittivity, dielectric loss for all composites increase with increasing the Egg shells filler content, or temperature which has been attributed to interfacial polarization and segmental mobility of the polymer molecules, respectively. The permittivity decreases with the increasing of frequency because interfacial and segmental mobility polarizations cannot keep up orientation in the direction of the alternating field. The impedance of the composite decreases with the increase of filler content, frequency and temperature

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