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The particle size effect of rice husk on thermal conductivity and dielectric constant of RTV Silicon rice husk composites

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The particle size effect of rice husk on thermal conductivity and dielectric constant of RTV Silicon rice husk composites

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Abstract. The rice husk (RH) is a wide agricultural resource by-product of rice milling process in Iraq. In this work, RH is used as filler to modified thermal conductivity and dielectric constant of RTV silicone. RH-RTV silicone composites are prepared with different RH filler particle sizes, they are equal to 6.5mm (raw RH), 1.18mm, 250 µm, 125 µm, 75 µm, and 50µm. The levels of RH filler loading (1, 3, 5, 7, 10, 15 and 20) (wt %). The thermal conductivity and dielectric constant of all RH-RTV silicone composites are studied. The effect of varying frequency (from 500 Hz to 1 MHz) on dielectric constant all composites is studied. The thermal conductivity of RH-RTV silicone composites decrease with RH filler concentration increases and particle size decreases, thermal conductivity has minimum value at 20%wt. The particle size effect on thermal conductivity of composite is very observably at 50µm particle. The dielectric constant of RH-RTV silicone composites is increased when RH filler concentration increases and particle size decreases, thy have maximum value at 20%wt and 50µm RH particle. The varying of frequency is low effect on 50µm RH-RTV silicone composites.

1. Introduction

RTV silicone is easy used; it has many applications in day life. RTV silicone alone does not result in better thermal and electrical insulations. Rice husk (RH) is a wide agricultural waste produce resource by-product of rice milling process in Iraq. It may be used as filler, the compound of RH is mainly a higher siliceous structure for the production of calcium silicate, this material has good heat insulating properties with a powerful thermal control of 1000C [1]. This designates that rice husk has relative heat resisting ability. A study of RH chemical composition displayed that RH need to 30 - 50 minutes to burn. The study indicated that fire ignition is dissipated by RH material [2]. The rice husk has a good dielectric property [3]. RTV silicone may be adding rice husk fillers as composite that allows for better enhanced of thermal insulation and also electrical properties.

Many studies use the rice husk as thermal/electrical insulation material or as a filler with different matrix. Rice Husk, Bagasse and Corncob were used as composites. The increasing percentage of rice husk decreased thermal conductivity [4].The rice husk was added to Plaster of Paris, thermal conductivity of paris plaster was decreased as the rice husk increased [5]. Rice Husk was added as filler reinforcement performance thermal insulation in epoxy matrix. These composites are found to possess sensible mechanical and thermal insulation, when filler increased the thermal conductivity is decreased

[6]. Rice husk (200 µm mesh) results in decrease of thermal conductivity of epoxy resin and there by develops its thermal insulation capability [7].

Rice husk was used to improve dielectrics properties of polyester resin and methyl ethyl ketone peroxide matrix, dielectrics properties were measured over 12.4-18 GHz frequency range, dielectrics properties of all composites samples were showed that dielectric properties were improved when Rice husk was increased [8].

2. Experimental details

Composites of different compositions are showed in table 1. Rice husk was gathered from local rice mill of Najaf, Iraq. RTV silicon rubber (RTV 615) was purchased from the Silmid England. Rice husk was washed carefully to eliminate dust, soil, sand, and rice particles; then it was dried. After that rice husk was grind using hammer mill before being sieved. Rice husk (RH) was separated into various RH particle sizes which is equal to 6.5mm (raw RH), 1.18mm, 250 µm, 125 µm, 75 µm, and 50µm levels of filler loading (1, 3, 5, 7, 10, 15 and 20 wt. (%). silicone rubber and RH were mixed with manual mixing technique. The mixture is poured into a mold and it is placed into room temperature to 48 hour. The sample of thermal conductivity as circle shape with diameter 13 cm and thickness ≈ 1 cm.

Table 1. Particle sizes and wt.% RH of samples.

Samples	Samples	Samples	Samples	Samples	Samples	RH wt.%
RH size						
6.5 mm	1.18 mm	250 µm	125 µm	75 µm	50 µm	
A_1	B_1	C_1	D_1	E_1	F_1	1
A_2	B_2	C_2	D_2	E_2	F_2	3
A_3	B_3	C_3	D_3	E_3	F_3	5
A_4	B_4	C_4	D_4	E_4	F_4	7
A_5	B_5	C_5	D_5	E_5	F_5	10
A_6	B_6	C_6	D_6	E_6	F_6	15
A_7	B_7	C_7	D_7	E_7	F_7	20

the thermal conductivity was studied at 50º C by heat flow meter using thermal coefficient meter YBF-3 (Hangzhou Dahua Yiqi Zhizao Co. Ltd, Korea) [9]. Dielectric constants was measured at room temperature by using HIOKI IM 3570 with L2000 4-terminals probe in the frequency range of 500 Hz to 1 MHz with an oscillation voltage of 1.0 V (HIOKI Co., Japan). The sample of dielectric constant as circle shape with diameter 10 cm and thickness ≈ 0.5 cm.

3. Results and discussion

3.1. Thermal property:

Thermal conductivity of the specimens have been studied by hot plat method. The rate of heat flow, H can be defined by Fourier's law

$$H = -k\,A\frac{\partial T}{\partial x}$$

where k is the thermal conductivity, A is the area of the test piece normal to the heat flow and $\frac{\partial T}{\partial x}$ is the temperature gradient [10]. The thermal conductivity of insulating materials has been found to contrast with temperature, moisture content, density, direction of heat flow with regards to grain for fibrous materials, the existence of defects in the material and porosity [11]. Thermal conductivity for all different particle size samples is decreased with concentration of RH is increased as shown in figure (1), The result is agreement with [1], this may be due to rice husk has superior siliceous material for the production of calcium silicate [12] thermal conductivity of the RH material which produced lower thermal conductivity [13],[14],[7]. Also figure (1) shows the thermal conductivity of RH-RTV silicon composites are decreased with particle size is decreased, this may be due to the smallest size of RH particle has more surface area and number, so more distribution and unformed in RTV silicon matrix, this impede the heat flow in composites[15].

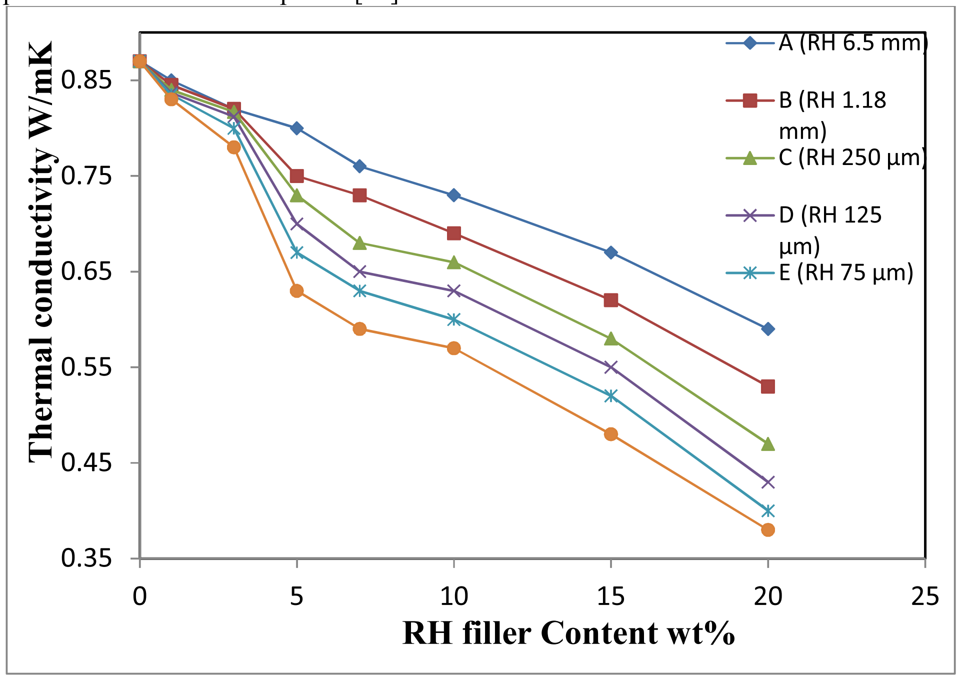

Figure 1. Thermal conductivity of RH- RTV silicon composites vary with content (wt %) and particle size of RH.

3.2. Electrical property:

Dielectric constant of the specimens have been studied. The dielectric constant, ε_r, is defined by the permittivity ε of the material with respect to that ε_0 of air or free space [16], Equation (2)

$$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0}$$

Figure (2) shows that at frequency 500 Hz, the RH-silicon composites dielectric constant are increased with RH concentrations are increased. The addition of RH with dielectric constant higher than the base RTV silicon increases the dielectric constant RTV silicon composite, mainly due to the influence RH dielectric constant [3]. The RH composition partially is formed silica then silica increases dielectric constant of RH [17].

It can also be shown that by increasing the RH filler content in RTV silicon rubber the dielectric constant increases [8].The highest dielectric constant of RTV silicon composites with all different particle size of RH filler is observed at highest RH content of 20% wt. it can be seen in the same figure the effect particle size on RTV silicone composite for dielectric constant. 50 µm composite (F samples) display a higher dielectric constant value than the big particle sized composite, the reasons may be explained this remark, (1) the small particle may be more distribution in silicon matrix than coarse particle. (2) the small particle may be restriction RTV silicone chain mobility in small particle sized composites [18].

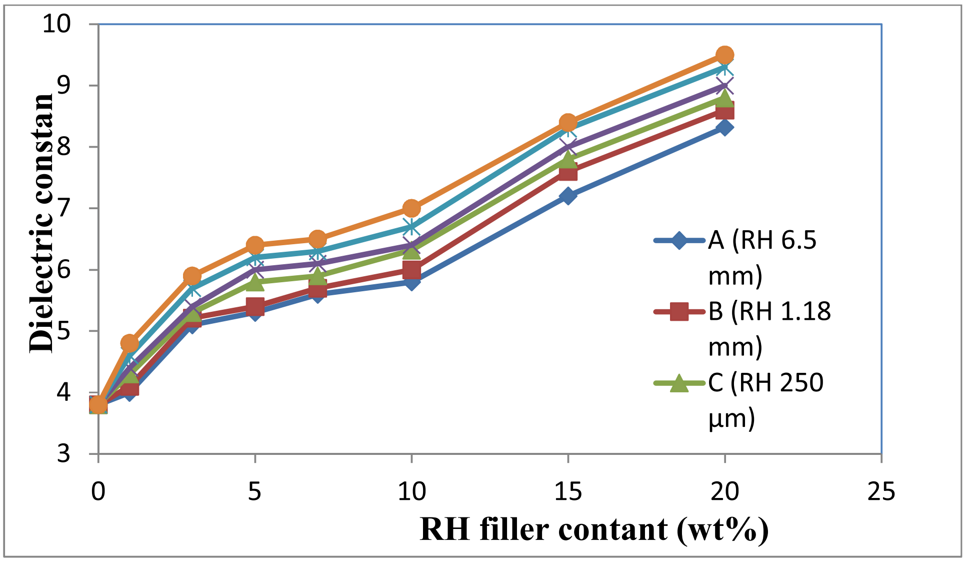

Figure 2. Dielectric constant of RH- RTV silicon composites vary with content (wt %) and particle size of RH.

Figure 3 shows variation in dielectric constant of silicon composite at RH content 20 % as a function of frequency. The dielectric constant decreases as the frequency is increased in range (500-1M)HZ. This behavior of the RH-RTV silicone composites may be explained as high dislocation density nearby the interface. Dielectric constant in order depends on the number of charge carriers in the bulk of the material, the relaxation time of the charge carriers and the frequency of the applied electric field. Because of the temperature of measurements is preserved constant, their effect on the relaxation times of the charge carriers is ignored. From above the current frequency range of measurement, charge transport will be mostly prevailed by lighter electronic species. In this condition the electrical properties of RH filler were nearly conquered, so a network may be started to join filler particles one by one, this network disconnect the silicone matrix [19].

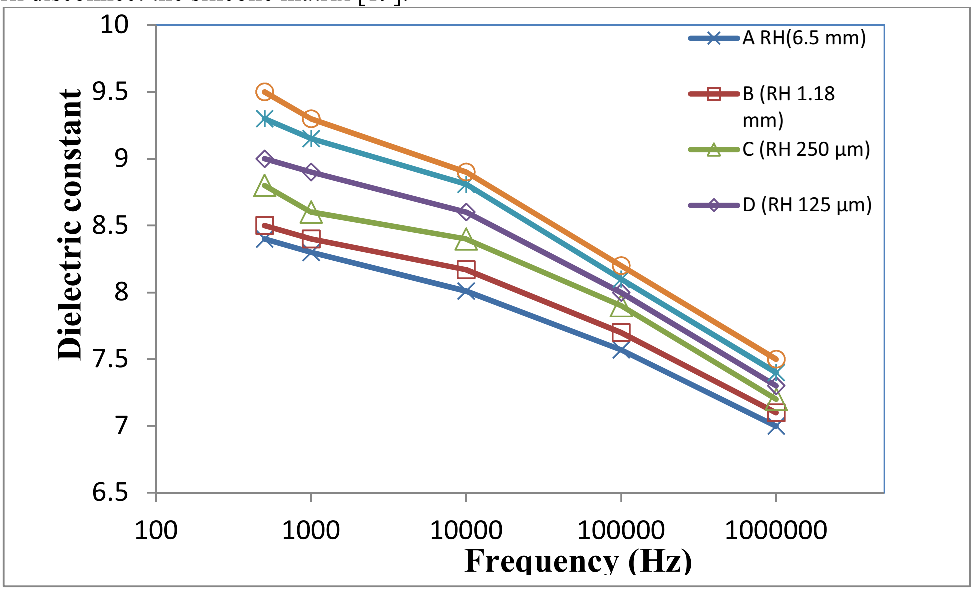

Figure 3. Dielectric constant varies as a frequency function RH- RTV silicone composites at RH filler 20% wt.

4. Conclusions

In this study, the concentration and particle size of RH filler has obviously effect on thermal and electrical properties of RH-silicon composites, it can be concluded:

1- The RH filler can be used to decrease the thermal conductivity of RTV silicon composites by increasing concentration (wt %) of RH filler. The decrease particle size of RH filler has similar effect of that RH filler concentration.
2- Dielectric constant of RTV silicon composites can be increased by increasing the RH filler concentration and decrease the particle size of RH filler.
3- The effect of highest frequency is low effect on the dielectric constant of RTV silicon composites of smallest RH particle size.

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