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Epoxy/Silicone Rubber Blends for Voltage Insulators and Capacitors Applications

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Abstract

In this research the epoxy/silicon rubber blends were prepared by adding the silicone rubber with varying weight (0.0, 0.25, 0.5, 0.75 and 1gm) to epoxy resin. Some thermal properties are determined for different samples of blends. The bulk resistivity and dielectric constant were evaluated and related to the neat epoxy. The results suggest that the inclusion of silicone epoxy effectively improved in the glass transition temperature (Tg) and the thermal insulation also improved the electrical properties like resistance and dielectric constant for using it as capacitor at high frequencies and in the high voltage strength applications.

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Keywords: Epoxy resin, Silicone, Dielectric constant, DSC, voltage insulators.

1. Introduction

Epoxy resin has a good chemical stability at high ranges of temperatures with low toxicity [1, 2]. The epoxy using to repair plastic pipes and using in electrical applications [3, 4]. The polymeric composite materials were using as insulators at high voltage applications because of the low coast, light weight, good mechanical strength [5, 6]. In this research we improvement the thermal and electrical properties of epoxy by blending the epoxy with silicone. Silicone rubber has been used in electrical service for over 50 years because of its impact resistance, light weight and

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performance environments [7]. The glass transition temperature Tg is the temperature at which the polymer becomes at soft state or rubbery due to the change in polymer chains mobility, Tg is an important property to give an idea about the polymer endurance to the maximum temperature, where the characteristic of the polymer especially the mechanical properties are different under and above the glass transition temperature of the polymer. While the second thermal property of a blend is thermal conductivity was the heat transfer by phonons in materials [8, 9]. Also the epoxy / silicone blends were prepared as good electrical insulators at low and high ranges of frequencies where the silicone resin (polydimethylsiloxane PDMS) is considered to be one of the most modifier agents especially for epoxy resin [10, 11].

2. Materials and Methods:

2.1. Preparation of Blend.

Laminates are prepared by hand lay-up technique, the blends are prepared from epoxy (matrix) and silicone rubber (reinforce), the epoxy (DCP, Quickmast 105, density 1.1±0.05, made in Jordan) mixed with its hardener triethylene tetra amine (TETA) (same company) at ratio3:1by weight, with mixing time (15) minute. The transparent sealant silicone rubber (polydimethylsiloxane, JOBO, Turkey) is added with different weight (0, 0.25, 0.5, 0.75, and 1gm) as shown in table (1). Before that the silicone rubber was mixed well with sufficient amount of ethanol till it looks like a gel form and converts to the white colour, in order to ensure a homogeneous mixture because both silicone and epoxy are sticky. The hardener ratio for all samples has been fixed when the weight ratios of the silicone rubber were added. The specimens were caste with hand lay-up technique in moulds with a disc shape (2.5 cm diameter) then left at room temperature for 24 hours in the moulds. After that the blends were removed from the moulds and cured further at temperature 70°C for (4) hours in an oven to treatment.

Table (1) Material ratios

Code	Matrix(EP) (gm)	Reinforcement(Si) (gm)
A	4	0
B	3.75	0.25
C	3.5	0.5
D	3.25	0.75
E	3	1

2.2. Methods.

The glass transition temperature (Tg) of epoxy/silicone blends was measured by DSC (DSC131Evo, France) with temperature range (20-200) °C and heating rate (5 °C/min). (10mg) of blend material were analyzed according to ASTM-D3418 [12]. The electrical properties determined using LCR Meter (6500p series, UK). Dielectric strength test was determined using breakdown voltage. The thermal conductivity was measured by using lee disc

3. Results and Discussions.

The thermal analysis property shows the heat flow as a function of temperature as shown in the figure (1) where we can get the glass transition temperature (Tg) of the prepared blends. Table (2) shows a small increasing of (Tg) with loading of silicone to epoxy which attributed to the low molecular weight between methyl groups and the flexibility of the silicone rubber chain[7], where the 0.75gm of silicone is the best value of loading to epoxy compared with Tg value of the neat epoxy resin (58 °C). In general, the samples exhibited a single glass transition, which refers to the presence of closed network or cross-linked structure[10] also noticed that the overloading silicon resin did not show significant change in the (Tg) value due to the interlacement of polymeric chains between the two phases, also it can be observed a decrease in the transition temperature value with more silicon loading this may due to acting as plasticizer phase in the matrix consequence reducing the stiffness of the blend [11] .So, we can say that the ratios (0.25, 0.5 and 0.75 gm) are suitable to make full interaction between silicone rubber and epoxy matrix and that cause a rigid blends, this rigidity increase with increase the silicone rubber in epoxy matrix and then increase in glass transition temperature value of blend. The ratio (1gm) of the silicone rubber is not suitable to make full interaction between silicone rubber and epoxy matrix, only a semi interaction will a occur and the silicone rubber separate from epoxy matrix, so this blend (1gm of silicone) is not rigid and the glass transition temperature decrease. Figure (2)

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