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Research Article

Electrical Resistivity Study for Unsaturated Polyester Reinforcement Glass Fiber

Rusul M. Abd Alradha[Å*]

[Å]Materials Engineering College, Babylon University, Iraq

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Abstract

In this study, the unsaturated polyester (UP) composite resin was used for binding the reinforcement such as glass fibers (GF) and polyvinylchloride (PVC) powder. Electrical resistivity of polymer composite has been investigated at different ratios of glass fiber and different temperatures. Results show that the electrical resistivity decreases with increasing temperatures and increases with increasing the concentration of GF% in the composite until reaching GF ratio of 20% then starts to decrease.

Keywords: *Unsaturated polyester, glass Fiber, PVC powder, electrical resistivity.*

Introduction

The work in this investigation was planned in order to obtain further information about the effect of addition of glass fiber to the unsaturated polyester resin on the electrical resistivity of polymer composite. The uses of composites as dielectric are becoming more popular, therefore the electrical properties of glass fiber reinforced polymer composites are very important (A. Paul *et al*,1997; J.D. Reid *et al*,1986). Composites materials, including polymeric composites with glass fiber additive are gaining increasing importance among the assortment of materials of industrial application. For instance, polymeric composites with glass fiber have been widely used for many innovative applications in aerospace, civil construction, automotive, energy, power cable, chemical and process industries. Therefore, in recent years, study of mechanical and electrical properties of polymeric composites, with the aim of developing scientific basis for the technology of their preparation, their optimal design and forecasting their working life has become an important problem (J. A. Epaarachchi,2006; A. Pawlak,2007) .

Among the reinforcement materials, glass fibers are popular candidates owing to their improved physical and mechanical properties, good corrosion resistance, insulation and sound absorption properties. Glass fibers are widely used as mats, insulator, reinforcement, sound absorption, heat resistant fabrics, corrosion resistant fabrics and high strength fabrics (A. K. Ruhul *et al*,2010 ; N.M.Cameron,1968). In Ref. (N.S.M. El-Tayeb, 2008), quite a few number of practical applications of natural fiber reinforced composites reported.Most organic polymers have medium to excellent electrical properties. Wide ranges of thermoset and thermoplastic materials are used in the electrical and electronics industries. Applications in which polyester resins have been used include the insulation of motor windings, encapsulation of electrical components, fabrication of printed circuit boards, high-voltage standoff insulators, switch boxes, and miscellaneous equipment for high-voltage line work (E. Dorfman *et al*,1977). Fiber reinforced composite materials have wide range of applications in aircraft automobile, chemical, medical and electrical industries. In the electrical or electronics industry, these composite materials are used for making panel, switches, and insulators(S. K. Khanna *et al*,2003 ; H. F. Wu *et al*,1997).

Experiment

This section describes the materials used in the production of the specimens, mix proportion and the method of testing. The specimens were cast, it are cured for one hour in 100 °C.

Matrix Material

Unsaturated polyester resin (UP) was used as the matrix in the preparation of composite material polymeric and manufactured by the (Industrial Chemical of resins Co. LTD) inSaudi Arabia. This resin transforms from liquid to solid state by adding (Hardener) and this hardener is manufactured by the company itself and it is a (Methyl Ethyl Keton Peroxide) coded (MEKP) and be in the form of a transparent liquid. It is added to the unsaturated polyester resin 1% percent at room temperature, and in order to increase the speed of hardening, catalyzer materials on interaction is used as a catalyst (Catalyst) called accelerators. Cobalt Napthenate which are mixed directly with the resin and manufactured by the same company.

*Corresponding author: **Rusul M. Abd Alradha**

Table 1: Demonstrate the physical and mechanical properties of GF

Modulus of elasticity GPa	Density g/cm^3	Diameter µm	Tensile strength MPa	Percent Elongation (EL%)	Coefficient of thermal expansion 10^{-6} (°C)$^{-1}$	Thermal conductivity W/m.K	Specific Heat J/kg. K
72.5	2.58	8-14	3450	4.3	5.0	1.3	810

Reinforced materials

In this research glass fibers used from type (E-Glass) as strengthening phase in the form of choppy glass fibers with different percent (5%, 10%, 15%, 20% and 25%), average diameter of filament for this choppy glass fibers is (8–16 µm)and with length is (0.02-0.08 mm).These fibers provided by (Mowding LTD. UK)English company.

While PVC is a thermoplastic polymer. It is a vinyl polymer constructed of repeating vinyl groups (ethenyls) having one of their hydrogens replaced with a chloride group. PVC is the third most widely produced plastic, after polyethylene and polypropylene. PVC is widely used in construction because it is cheap, durable, and easy to assemble. In this study PVC (density 1.39 g/cm^3) was used in constant percentage (10%) with size particulate (300,154 and125 µm).This mixture transforms to solid state for one hour and the mixture was used as fixed length 165 mm.

The electrical resistivity (ρ) determination

It can be calculated by using LCR meter and following the equation below. The samples were fixed between two electrodes.

$\rho = RA/t$

where,

A - area of cross-section of the sample.
R – resistance.
t - thickness of the sample.

Results and Discussion

Fig (1) shows that electrical resistivity is increased with increasing GF ratio since The resistivity of fiber reinforced composites depends on the moisture content, crystalline or amorphous component present, presence of impurities, chemical composition, cellular structure and micro fiberillar angle etc. So such electrical resistivity increase may be due to hydrophobic nature of glass fiber after GF ratio 20% electrical resistivity begins to decrease because of the large GF ratio in compound so the resistivity tends to be close to the glass fiber value which is ($4.02*10^{12}\Omega$.m) (H. David *et al*,1996 ; A. Akinci,2010) . While this resistivity decrease with increasing temperature. The reason for such decrease in resistivity can be explained by considering the flow of current through the material. The flow of current is actually the movement of electrons from one atom to another under the influence of an electric field. Electrons are very small negatively charged particles and will be repelled by a negative electric charge and attracted by a positive electric charge. Therefore if an electric potential is applied across a conductor (positive at one end, negative at the other) electrons will migrate from atom to atom towards the positive terminal. Only some electrons are free to migrate however. Others within each atom are held so tightly to their particular atom that even an electric field will not dislodge them. The current flowing in the material is therefore due to the movement of free electrons and the number of free electrons within any material compared with those tightly bound to their atoms is what governs whether a material is a good conductor (many free electrons) or a good insulator (hardly any free electrons).
In an insulator. There are so few free electrons that hardly any current can flow. Almost all the electrons are tightly bound within their particular atom. Heating an insulating material vibrates the atoms, and if we heated sufficiently the atoms vibrate violently enough to actually shake some of their captive electrons free, creating free electrons to become carriers of current. Therefore at high temperatures the resistance of an insulator can fall, and in some insulating materials, quite dramatically.

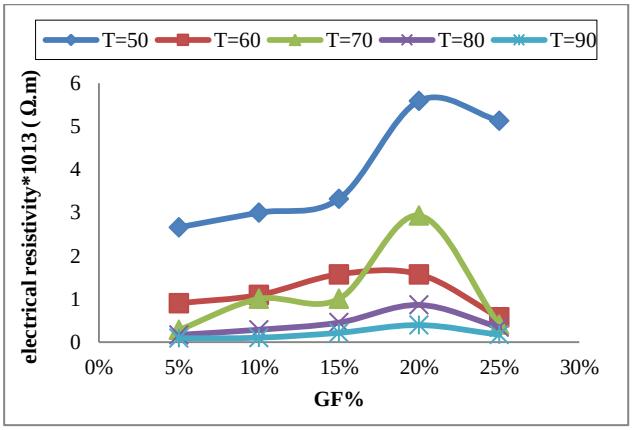

Fig (1): illustrate electrical resistivity with GF percentage at different temperatures.

Conclusion

1-Electrical resistivity increases with increasing GF ratio may be due to hydrophobic nature of glass fiber until reaching GF ratio of 20% then starts to decrease because of the large GF ratio in compound so the resistivity tends to be close to the glass fiber value which is ($4.02*10^{12}\Omega$.m).
2- Electrical resistivity decrease with increasing temperatures because of Heating an insulating material vibrates the atoms, and if we heated sufficiently the atoms vibrate violently enough to actually shake some of their captive electrons free, creating free electrons to become

carriers of current. Therefore at high temperatures the resistance of an insulator can fall.

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