Elastic and Electrical Properties of Graphite and Talc Filler Reinforced Polypropylene (PP) Composites

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***Abstract*--** **Graphite filler reinforced polypropylene (PP) composites and talc filler reinforced (PP) composites were prepared by compression molding at 160 ^{0}C. Mechanical and electrical properties were studied. The tensile strength of the composites decreases with the increase of filler addition and also with the increase of wt.% of filler. But, a slight improvement of the Young's modulus of the filaments reinforced with different wt.% of filler is observed. It was found that the Bulk density of test materials increased with the fillers content. Capacitance decreases with the increase of both frequency and voltage which suggest good electrical properties of PP-graphite composites and PP-talc composites. All of these results indicated that PP-graphite composites are better than the PP-talc composites.**

***Index Term*--** **Reinforced polypropylene (PP) composites, mechanical properties, electrical properties, Young's modulus and bulk density.**

1. INTRODUCTION

A polymer is a versatile material. In the present era of science is the most promising and comprehensive field. Development of polymer is a continuous process for achieving polymer in a specific application under certain environmental condition [1]. The bombardment of the invention of different polymer field is increased day by day. Today synthetic polymers are combined with various reinforcing fillers in order to improve the mechanical properties and obtain the characteristics demanded in actual applications [2- 4]. Two of the main parameters affecting the properties are processing condition and interfacial adhesion [5]. Polypropylene (PP) is an attractive candidate for many engineering applications because of its excellent chemical resistance, acceptable range of tensile strength and modulus, good impact strength and processability, and low price [6]. There are many ways in which the mechanical properties of polypropylene can be modified to suit a wide variety of end-use applications. Various and reinforcements, such as graphite, talc, and mica, are typical ingredients that are added to polypropylene to attain cost-effective mechanical properties. Fibrous materials tend to increase mechanical properties, such as tensile and flexural strength, flexural modulus, creep resistance, and even impact strength. Fillers, such as graphite and talc, are often used as extenders to reduce the final material cost [7].

Polypropylene (PP) is one of the most extensively used plastics both in developed and developing countries. It provides advantages in regard to economy (price), ecological (recycling behaviors) and technical requirements (higher thermal stability) efficiency filler reinforced composite depends on the filler matrix interface and the ability to transfer stress from the matrix to the filler [8]. Graphite is pure carbon in a crystal form much like that of mica–sheets of strongly linked atoms, with very weak bonds between the sheets. This structure makes graphite an excellent dry lubricant wherever temperatures do not get too high. Graphite is very soft, measuring 1 or 1.5 on the Mohs scale of mineral hardness [5]. Polymeric graphite fibres composite is the material of choice for applications where lightweight & superior performance is paramount, such as components for spacecrafts, fighter aircrafts, and race cars. Composite materials are extremely versatile. The engineer can choose from a wide variety of fibres and resins to obtain the desired material properties. Also the material thickness and fibre orientations can be optimized for each application. The influence of graphite additions on the friction and wear behaviour of moulded epoxy resin has been evaluated using a pin-on-disc wear unit under dry sliding conditions. Graphite addition reduces the friction coefficient. Further, wear loss drops significantly when graphite is present in small amounts in the resin. The tests conducted on the composites containing 3wt% or more of graphite yielded extremely small amounts of wear [9]. On the other hand, talc is water repellant and very soft. It can resist temperature up to 900°C, is unaffected by chemicals and will not harm living tissue. Talc can be utilized as a medium filler of average whiteness in thermosetting as well as thermoplastic resins where improvements in electrical insulation, heat, and moisture resistance, chemical inertness and good machinability are needed. Talc has low absorption rate and because of its plate like structure, certain grades can improve flexural properties of mouldings.

2. EXPERIMENTAL DETAILS

In this work compression molding process is used to make die for casting with desired size. A die was made which has a ring of inside diameter 146 mm and outside diameter 158 mm, and have two disc (or plates) on each side, each of 7.5 mm in thickness. In compression molding, the polymeric materials and the fiber are subjected to heat and pressure in a single stroke. This is accomplished by using a hydraulic press with heated platens. Molding temperature and pressure can be as high as 250oc and 250 KN, respectively. The actual temperature and pressure depends on the theological, thermal, and other properties of the plastic and fiber materials to be molded. The materials are placed into the die

so as to fill the die. As the mold closes down under pressure, the material is squeezed or compressed between the two halves and compacted to shape inside the die. The excess material flows out of the mold as a thin film. This film expelled out of the mold is known as the "flash". Under the influence of heat, the compacted mass get cured and hardened to shape. After completion of heating, the mold is allowed to cool down. When cooling is completed the cold mold is then demolded by hand or any suitable device.
Mechanical properties such as tensile strength, elongation at break, tensile Modulus, bending strength and bending modulus etc were determined by Universal testing machine (model 1011UK, INSTRON Corporation). There was a fixed jaw and a movable jaw. The sample was inserted within this jaw and then pressure was applied by an input system. The various data (tensile strength, elongation at break etc) was obtained from the output system. A LCR meter was used to measure the inductance, capacitance and, resistance of a component.

3. RESULTS AND DISCUSSION

3.1 MECHANICAL PROPERTIES

The performance and durability of composites are dependent on the mechanical properties. The interaction between organic and inorganic materials is very slight. The addition of graphite and talc, the higher the elastic modulus while the lower the maximum tensile strength and the tensile strain. The reduction of elongation at break values with increasing graphite and talc is indirect evidence that implies the bonding is poor. Fig. 1 shows the variation of wt.% on tensile strength. The increase of tensile strength is caused by the decrease of wt.% of graphite and talc filler on the composites.

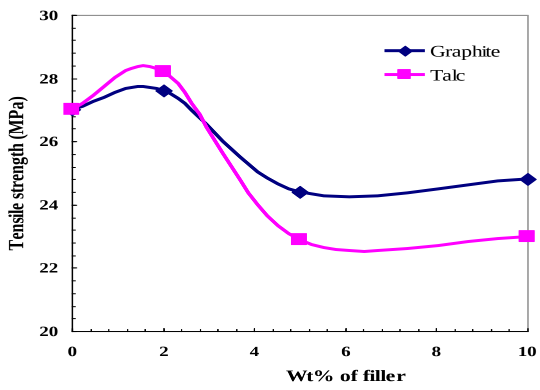

Fig. 1. Effect of variation of wt. % on tensile strength of PP-graphite and PP-talc composites.

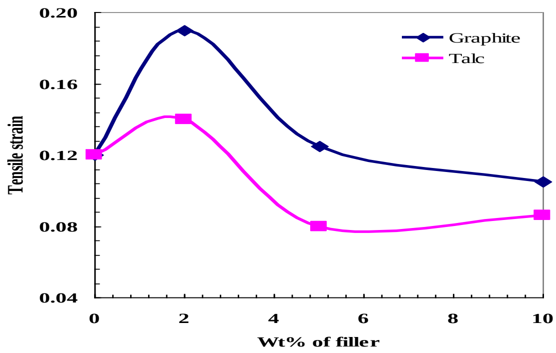

Fig. 2. Effect of variation of wt. % on tensile strain of PP-graphite and PP-talc composites.

The maximum tensile strength is found for 2% graphite content composite and the value is 28.46604MPa.On the other hand, 2% talc content composite shows maximum tensile strength which accounts for 28.74016MPa. But in this figure, it is evident that the tensile strength is smaller for talc rather than graphite.
Fig. 2 shows the variation of wt % on tensile strain. The increase of tensile strain is caused by the decrease of wt % of graphite and talc filler on the composites. 2% of graphite composite shows maximum tensile strain which stands for 0.19272 whereas 2% talc composite also shows highest value for tensile strain and the value is 0.13328. From this figure it is clear that graphite filler content composite shows better result than talc filler content composite.
Fig. 3 represents the effect of Young's modulus of composites. It reveals that Young's modulus decreases with the increase of wt.% of filler. Young's modulus is a measure of stiffness of a material. Thus, stiffness of the composites decreases with the addition of filler. The highest value of Young's modulus for graphite reinforced PP composite is 439.46850MPa and the highest value for talc reinforced PP composite is 385.3959MPa. It is manifest that the Young's modulus is larger for graphite rather than talc filler content composites.

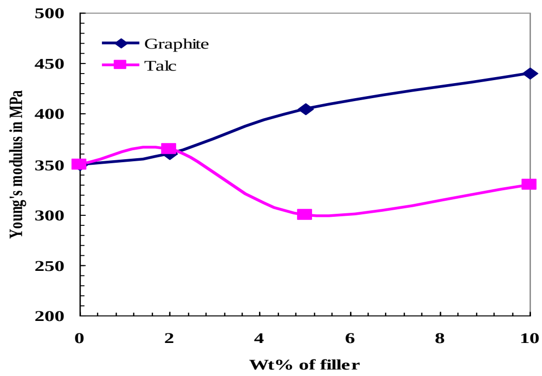

Fig. 3. Effect of variation of wt. % on Young's modulus of PP-graphite and PP-talc composites

3.2 ELECTRICAL PROPERTIES

Polymer-mineral filler composites can be used as dielectric materials. Frequency has an important influence on dielectric properties. Fig. 4 and Fig.5 show the variation of capacitance for wt.% of graphite fiber with frequency from 100Hz to 100KHz at room temperature.

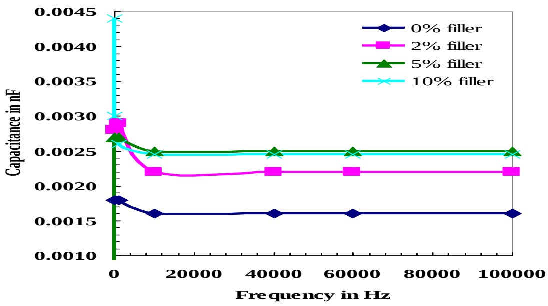

Fig. 4. Effect of frequency of PP-graphite composites on capacitance.

It is observed that the capacitance increases slowly with increasing frequency up to 10KHz then it remains nearly constant. The 5% graphite filler content composite has higher capacitance which corresponds to higher dielectric constant. Therefore, 5% graphite filler constant composite shows the better electric properties. In case of talc filler content composites, 10% talc filler shows the better electric properties because of higher capacitance and as well as higher dielectric constant.

Fig. 6 shows the effect of frequency between PP-graphite and PP-talc composites. Capacitance and dielectric constant are higher for PP-graphite composite than PP-talc composite. From this figure it is evident that the graphite filler content composite shows better electric properties than talc filler content composite.

The capacitance-voltage (C-V) measurement can be used to determine the interface quality. During the C-V measurement the device is swept from accumulation to inversion while constantly measuring the capacitance as C = Q/V and this technique is used for characterization of composites.

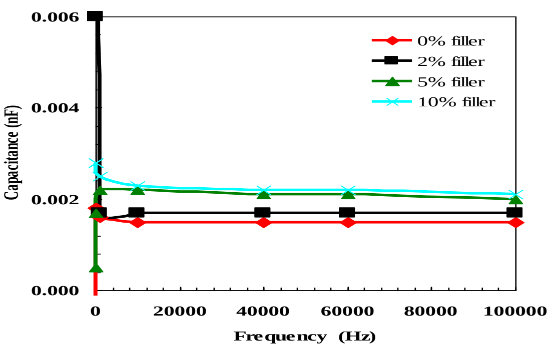

Fig. 5. Effect of frequency of PP-talc composites on capacitance

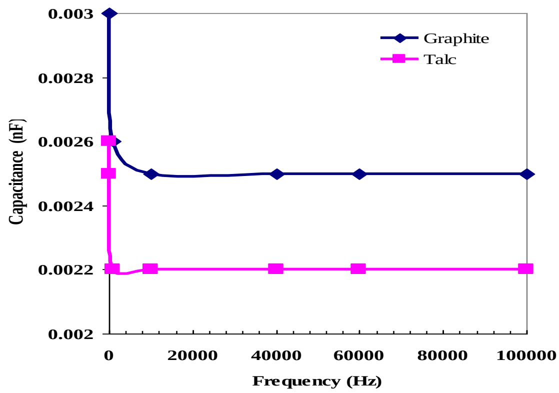

Fig. 6. Effect of frequency of PP-graphite and PP-talc composites on capacitance.

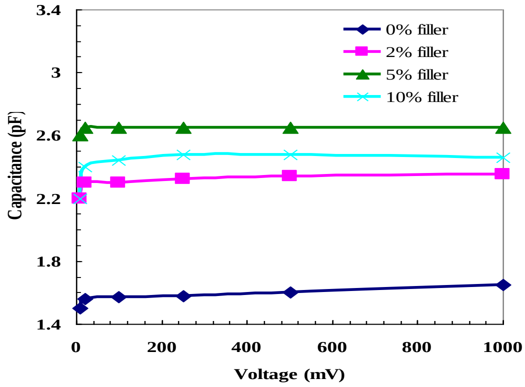

Fig. 7. Effect of voltage of PP-graphite composites on capacitance.

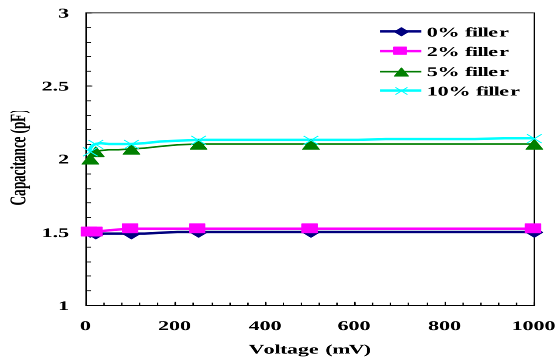

Fig. 8. Effect of voltage of PP-talc composites on capacitance.

Typical plots of capacitance against voltage at room temperature are shown in Fig. 7 and Fig. 8 for PP-graphite and PP-talc composites, respectively. It is seen that the capacitance remains steady with increasing voltage. From these two figures, it is clear that the capacitance of the composites increases with the increase of voltage. But the graphite filler content composite has higher value of capacitance than the talc filler content composite.

4. CONCLUSIONS

The result of the present study reveals that composites with good strength could be successfully developed using graphite and talc as the reinforcing agent. But the graphite filler content composites show better result than talc filler content composites. PP-graphite and PP-talc composites demonstrate good mechanical strength and can be used as environmentally degradable thermoplastics. Tensile strength of PP-graphite and PP-talc composites decreases with the increase of filler addition. Tensile strength is higher for graphite filler content composites than talc filler. Electrical conduction in these composites is probably due to both ions and electrons. The conductivity dependence on frequency is an indication of hopping conduction.

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