Mechanical Responses of Polypropylene and Calcium Carbonate Nanoparticles

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***Abstract* - This paper is to study the mechanical behaviour and properties like tensile, impact and flexural on the composite mixture of polypropylene and calcium carbonate nanoparticles. Four compositions of Polypropylene and $CaCO_3$ nanocomposites were prepared in Injection molding machine with varying calcium carbonate percentage. The results are plotted and it shows the increase in polypropylene elastic modulus and a little increase in yield stress, the impact resistance increased with the addition of nanoparticles. Tensile property and flexural depends on the calcium carbonate dispersion in polypropylene.**

I. INTRODUCTION

A composite material is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure, differentiating composites from mixtures and solide solutions, typical engineered composite materials include,

Reinforced concrete and masonry, Composite wood such as plywood, Reinforced plastics, such as fibre-reinforced polymer or fiberglass, Ceramic matrix composites Metal matrix composites and other Advanced composite materials. Polypropylene is a semi crystalline polymer that exhibits very attractive mechanical properties, like ductility and strength at room temperature or under moderate rates of deformation. However, under severe conditions it becomes brittle [1]. This behavior makes it interesting for commercial and scientific field to study methods for toughening these materials, also known as polypropylene. The thermoplastic polymer used in a wide variety of applications. An addition polymère made from the monomer propylene, it can be produced in a variety of structures giving rise to applications including packaging and labeling, textiles, plastic parts and reusable containers of various types, laboratory equipment, automotive components, and medical devices. It is a white, mechanically rugged material, and is resistant to many chemical solvents, bases and acids. Polypropylene is in many aspects similar to polyethylene, especially in solution behavior and electrical properties [2]. The methyl group improves mechanical properties and thermal resistance, although the chemical resistance decreases. The properties of polypropylene depend on the molecular weight and molecular weight distribution, crystal, type and proportion of comonomer (if used) and the isotacticity . In isotactic polypropylene, for example, the methyl groups are oriented on one side of the carbon backbone [3]. This arrangement creates a greater degree of crystalline and results in a stiffer material that is more resistant to creep than both ataxic polypropylene and polyethylene. The density of PP is between 0.895 and 0.92 g/cm³. Therefore, PP is the commodity plastic with the lowest density. With lower density, moulding parts with lower weight and more parts of a certain mass of plastic can be produced. Unlike polyethylene, crystalline and amorphous regions differ only slightly in their density. However, the density of polyethylene can significantly change with fillers. The Young's modulus of PP is between 1300 and 1800 N/mm². Polypropylene is normally tough and flexible especially when copolymerized with ethylene. This allows polypropylene to be used as an engineering plastic, competing with materials such as acrylonitrile butadiene styrene (ABS). Polypropylene is reasonably economical [3]. Polypropylene has good resistance to fatigue.

As polypropylene is resistant to fatigue, most plastic living hinges, such as those on flip-top bottles, are made from this material. However, it is important to ensure that chain molecules are oriented across the hinge to maximise strength. Polypropylene is used in the manufacturing piping systems; both ones concerned with high-purity and ones designed for strength and rigidity (e.g. those intended for use in potable plumbing, hedonic heating and cooling, and reclaimed water). This material is often chosen for its resistance to corrosion and chemical leaching, its resilience against most forms of physical damage, including impact and freezing, its environmental benefits, and its ability to be joined by heat fusion rather than gluing. Many plastic items for medical or laboratory use can be made from polypropylene because it can withstand the heat in an autoclave. Its heat resistance also enables it to be used as the manufacturing material of consumer-grade kettles. Food containers made from it will not melt in the dishwasher, and do not melt during industrial hot filling processes. For this reason, most plastic tubs for dairy products are polypropylene sealed with aluminium foil (both heat-resistant materials). After the product has cooled, the tubs are often given lids made of a less heat-resistant material, such as LDPE or polystyrene.

Calcium carbonate ($CaCO_3$) is a chemical compound with the formula $CaCO_3$. It is a common substance found in rocks as the minerals calcite and aragonite (most notably as limestone, which contains both of those minerals) and is the main component of pearls and the shells of marine organisms, snails, and eggs. Calcium carbonate is the active ingredient in agricultural lime and is created when calcium ions in hard water react with carbonate ions to create limescale. It is medicinally used as a calcium supplement or as an antacid, but excessive consumption can be hazardous.

Recently, $CaCO_3$ nano-particles were commercially available for toughening polymers. Although small and uniform particles are believed to be more effective in toughening than large ones, nano-particles the interfacial interaction between nano-particles and polymer matrix is one of the most important factors affecting the crystalline morphology of the nano-composites Calcium carbonate nano-particles have been widely used as fillers in polymeric materials with the main purpose of reducing costs[4], however recently works showed that the incorporation of calcium carbonate nano-particles can lead to higher impact resistance associated with higher elastic modulus. In order to increase the impact strength of polypropylene the incorporation of Calcium carbonate particles has been widely used which increases the impact resistance. It decrease compression set with increase of calcium carbonate and tensile strength increases with increase of calcium carbonate. So here we study the mechanical properties (tensile, compression) of polypropylene with mixture of nano- particle like calcium carbonate and form the product which can be used in dilly life with less toxic and less cost.

II. FABRICATION PROCESS

Preparation of the nanocomposites, before extrusion polypropylene and calcium carbonate nanoparticles were dry mixed in the desired compositions. Three compositions of nanocomposites with calcium carbonate content of 0 and 15 wt. (%) were prepared in a injection molding machine ,screw diameter of 30 mm, L/D = 35, speed rotation of 100 rpm and. The temperature pro was 170/190/190/190/190/195°C.

III. RESULTS AND DISCUSSION

A. Tensile Test Result

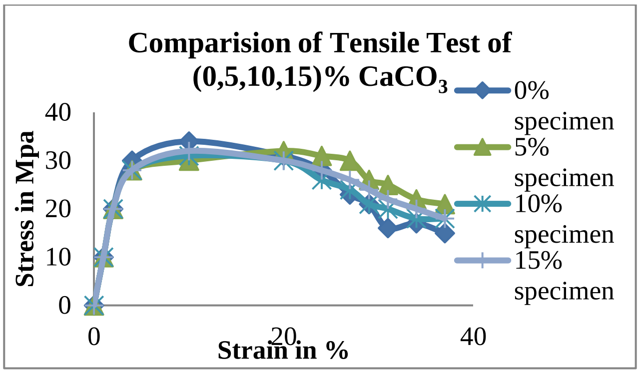

Fig. 1: Plots of comparison of tensile test results.

The ultimate tensile and elongation is maximum at 0% of $CaCO_3$ when its compare with 5, 10, 15 percentage of $CaCO_3$.

B. Impact Test

The impact strength is more in PP/5% $CaCO_3$ than when we compared with the polypropylene PP/(0,10,15)% $CaCO_3$, where has 0% CaCO3 has the lowest impact strength compared to all . The 15% $CaCO_3$ has more impact strength than 0% and where as the 10% $CaCO_3$ has a slight more impact strength than 15% $CaCO_3$.

C. Flexural Test

result of flexural strength is more in PP/15% $CaCO_3$ than when compared with polypropylene of PP/(0,5,10)% $CaCO_3$. Where 0% $CaCO_3$ has the lowest flexural strength compared to all the composite materials, the 5% $CaCO_3$ has a more flexural strength than 0% $CaCO_3$ and where 10% has $CaCO_3$ has a bit more flexural strength than 5% $CaCO_3$. With the increase of $CaCO_3$ content flexural strength of the composite material increases, the 15% has more flexural strength, has the ratio $CaCO_3$ decreases the flexural strength decreases.

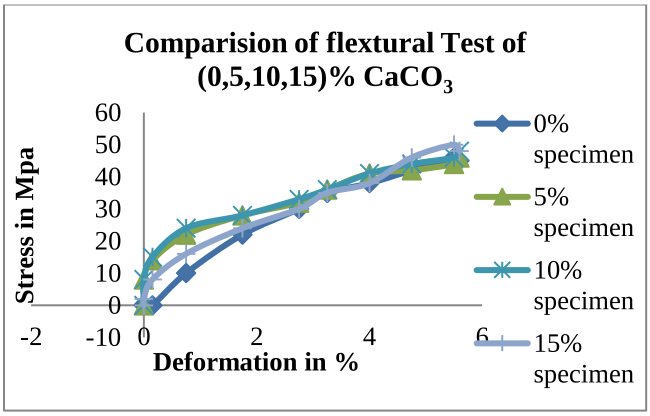

Fig. 1: Plots of comparison of flexural test results.

III. CONCLUSION

The results obtained in this work evidenced the influence of calcium carbonate nanoparticles in mechanical properties of polypropylene. Great increases in tensile breaking strain were obtained with the addition of content of 10 % $CaCO_3$, when we compared with the pure form of polypropylene PP/(0,5,10,15)% $CaCO_3$. Where has 0%$CaCO_3$ has a bit lesser tensile breaking strain, where has 15%$CaCO_3$ has a bit less tensile breaking strain compared to 0% $CaCO_3$, and when compared with 0% $CaCO_3$ the least tensile breaking strain is obtained in 5% $CaCO_3$.

The Great increases in impact strength is more in PP/5% $CaCO_3$, than when we compared with the polypropylene PP/(0,5,10,15)% $CaCO_3$. where has 0% $CaCO_3$ has the lowest impact strength compared to all . The 15% $CaCO_3$ has more impact strength than 0% and where as the 10% $CaCO_3$ has a slight more impact strength than 15% $CaCO_3$.

The results obtained in this work evidenced the influence of calcium carbonate nanoparticles in mechanical properties of polypropylene. Great increases in flexural strength is more in PP/15% $CaCO_3$ than when we compared with the pure form of polypropylene PP/(0,5,10,15)% $CaCO_3$. Where 0% $CaCO_3$ has the lowest flexural strength compared to all the composite materials, the 5% $CaCO_3$ has a more flexural strength than 0% $CaCO_3$ and where 10% has $CaCO_3$ has a bit more flexural strength than 5% $CaCO_3$.

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