Preparation and Study of Mechanical Properties of Nylon 66 / $CaCO_3$ Engineering Thermoplastic Composite

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Abstract:- **The thermoplastic materials, which has the capacity to withstand tensile pressure of more than 400 Kg/cm^2 and temperature of more than 100^{0}C considered as engineering thermoplastics. In this paper, a new composite of Nylon 66 has been prepared by adding micron-sized calcium carbonate ($CaCO_3$) filler aiming in improvement of the mechanical properties of Nylon 66. Directly a standard specimen is prepared by injection moulding process, it is a cyclic process of forming plastic into a desired shape by forcing the material under pressure into a cavity.**

Key words**: Nylon 66, composite, Caco$_3$, thermoplastic, filler**

I. INTRODUCTION

Nowadays, polymers and polymer based composites are used commonly in situations where a good tribological property is required. Homopolymers alone cannot satisfy the required properties for the tribological applications such as cams, brakes, bearings, gears etc.Thus, to improve properties and to lower the cost of polymer products, fillers are employed. The fillers can be in micro and nano sizes of inorganic fillers, organic fillers and metallic particulate materials.The tribological behaviour of polymers with the addition of fillers is of great interests in recent years to improve the friction coefficient and wear rate. (Difallah et al., 2012),

Nylon 66 is a well-known engineering thermoplastic polymer over the past decades. The mechanical properties of Nylon 66 have been in studies over the years. Hence, polymers containing inorganic fillers have been studied widely because of its growing industrial applications. Inorganic particulate fillers such as calcium carbonate, talc, mica, kaolin etc. of micrometre-sized particles are used to improve tensile strength, hardness,impact strength, toughness but in reductionof elongation(Wang et al., 2008). Calcium carbonate is one of the most important fillers used in polymer composites. It has emerged as a promising reinforcer due to its easy mix and processing and also it may improve the mechanical, tribological and rheological properties of polymer composites. (Lin et al., 2006). Calcium carbonate filled polymers are studied in many research articles related to the mechanical properties. (Tang et al. 2002).

According to study of tensile, impact and bending properties of $CaCO_3$ and hollow glass bead filled Nylon 66, it has reported that for the injection moulded specimens the tensile modulus increases with increasing ratio of fillers and tensile strength decreases gently with the increase of filler (Jiang et al. 2005). From the study of micron-sized and nano sized $CaCO_3$ with Nylon 66 it has been found that micron sized one is more effective than nano-sized $CaCO_3$.According to (Wang et al.2012), the mechanical and tribological properties of Nylon 66 filled with graphite and carbon black, it is concluded that the fillers can effectively decrease the COF and wear rate. Lin et al. have reported that the effect of $CaCO_3$ whiskers filled with polyether-ether-ketone (PEEK) has improved the tribological properties in dry sliding conditions. (Youxi et al. 2007) have also revealed that $CaCO_3$ whisker and poly-tetra-fluoro-ethylene (PTFE) can improve wear resistance with PEEK polymer. Hence, researchers have used Nylon 66 material by incorporating various fillers to study different mechanical properties. But, there has been a little investigation on the development of Nylon 66 polymer with micron-sized $CaCO_3$ conventional filler. To obtain the best results in mechanical properties, right amount of filler and operating conditions must be provided to get optimum responses. The present study investigates the mechanical behaviour of Nylon 66 / $CaCO_3$ composites. In this work, by taking various proportion of Nylon 66/$CaCO_3$ the mechanical properties are analysed and efforts are made to improve mechanical properties and decrease the elongation % of Nylon 66. An analysis between the theoretical properties of Nylon 66 and the Nylon 66 / $CaCO_3$ composite is being done.

II. EXPERIMENTAL DETAILS

2.1. Materials

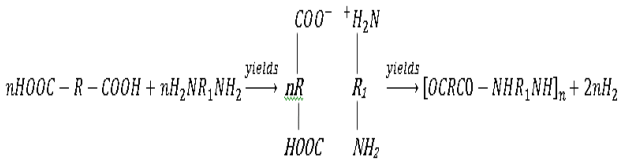
The material for the experiment is Nylon 66 supplied by shree bajrang traders and the filler selected is Calcium carbonate ($CaCO_3$) supplied by Gulsan Polyol Ltd,India in the form of

powder with a purity of 97%, mean particle size of 2 – 2.5 μm and bulk density of 2.71 g / cm^3.

2.2. Preparation of Nylon 66

The Nylon 66 is prepared from Nylon salt, which is prepared by reacting the hexamethylene diamine and adipic acid in boling methanol. The comparatively insoluble salt (Mp-190^o - 191^{o}C) precipitates out from methanol. A 60% aqueous solution of the salt is then run into a stainless-steel autoclave together with a trace of acetic acid to limit the molecular weight (9000-15000). The vessel is sealed and purged with oxygen free nitrogen and the temperature raised to 220^{o}C.

Apressure of 1-7 MPa is developed. After 1-2 hours, the temperature is raised to 270^o - 280^{o}C and steam bled off to maintain the pressure 1.7 MPa. (Technical manual plastic material, CIPET). The pressure is then reduced to atmospheric for one hour, after which the polymer is extruded by oxgen free nitrogen on to a water cooled casting wheel to from a ribbon, which is subsequently disintegrated.



2.3. Properties of Nylon 66

The properties of Nylon 66 are given in table 1. The properties of Nylon 66 are almost similar to that of Nylon 6 except that its melting behavior is different and absorbs more moisture.

Table 1 :Properties of Nylon 66

Properties	Unit	Value Nylon66
Tensile strength	MPa	80
Tensile modulus	MPa	3000
Flexural modulus	MPa	2414
Elongation at break	%	50
Impact strength	J/m	53
Hardness		M86

2.4. Processing of Nylon 66

The Nylon 66 is also processed with many precautions as like Nylon 6. The annealing temperature of Nylon 66 part is 149-177^{o}C. The Nylon 66 is processed in the temperature range of 275-305^{o}C. They are available in the similar grade like Nylon 6.

2.5. Apparatus and Methodology

The specimen is prepared by using injection moulding machine Electronica CPR-M-29. A heater is used for preheating the sample to remove moisture and it helps in melting.The tensile properties were measured at room temperature by means of testing machine UTE-20-HGFL. The tests were conducted according to ASTM E8 standard. The cross-head speed was set to 50 mm/min. The Charpy impact tests were carried out according to ASTM D256 standard. The bending properties were also measured at room temperature employing ASTM D790 standard. Each group of specimens for tensile impact and bending tests contained 3 pieces, and the average values of the mechanical properties were determined from the measured data.

2.6. Sample Preparation

Taking weight % of3, 5, 7 of $CaCo_3$ with 970, 950, 930 gm of ABS is taken for the study. These three sample of Nylon 66 is kept in to the heater andthen settingthe temperature range to 800^0 C for 2 hr for drying and removing the moisture content which helps in melting, then Nylon 66 is mixed with $CaCo_3$ of given % in a stirrer and stirred for 3min. Now the sample is ready for the injection moulding to prepare the specimen. The tensile and hardness specimen prepare of standard size for the injection moulding as shown in Figure 1.

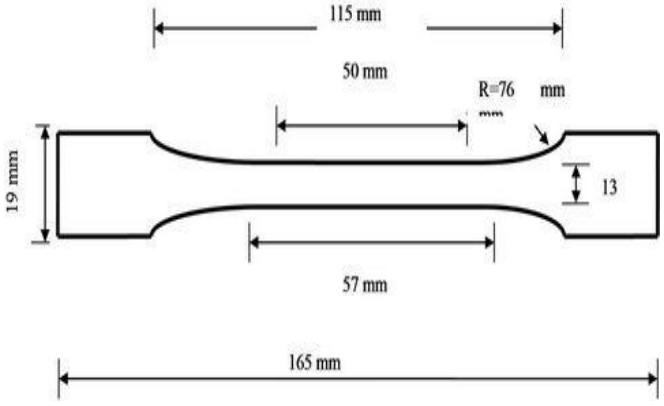


Figure 1. Standard specimen

2.7. Specimen Preparation

Standard size Specimen as shown in Figure 1 is prepared by injection moulding machine, CPR-M-29 moulding machine is used for moulding the specimen. Three numbers of specimens from each sample are prepared for testing.

III. TESTING

To know the mechanical properties of the component, various test like tensile strength, impact strength, hardness testwas carried out for the prepared specimen and are listed in the table2.

Table 2: Tested value of Nylon 66 and its composite with 5% CaCo3

MATERIAL	SAMPLE	TENSILE STRENGTH (MPa)	%OF ELONGATION	HARDNESS (R, M)
NYLON 66	1	80	50	M86
	2	81	51	M85
	3	79.5	50.25	M84
COMPOSITE OF NYLON 66	1	110	10	M120
	2	109	12	M117
	3	112	11	M115

3.1. Results

Tests were carried out for Nylon 66 and its composite of 3%, 5% and 7% CaCo3 in 1kg of Nylon 66. The test results have shown that addition of filler in Nylon 66 increases its tensile strength and reduces its elongation to a great extent.

3.1.1. Tensile Strength

Relation between tensile strength of Nylon 66 and 5% weight percentage of $CaCo_3$ is analysed in Figure 2. Three samples were taken and test is carried out and the test values are plotted below.

Sample one shows that in normal Nylon 66 tensile strength value is 80 MPa while by adding 5% $CaCo_3$ it increases to 110, in sample 2 it is shown that the value slightly decreases to 109 MPa and in sample 3 again tensile strength increases to 112 MPa. So it canbe said thatthe tensile strength may be increased by adding less than 5 %of CaCo3.

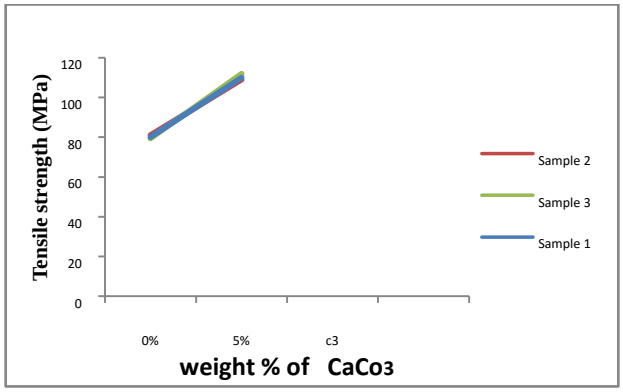


Figure 2 Relationship between Impact Strength of Nylon66 with Composite

3.1.2. Hardness

Nylon 66 material are generally less hardened than ABS but it can be increased by adding $CaCo_3$ filler into it. The Figure 3 showsthat the increase value of hardness of Nylon 66 by adding the filler. All the sample test value shows that by increasing filler, the hardness is increasing its value up to M117 by adding 5% of filler.

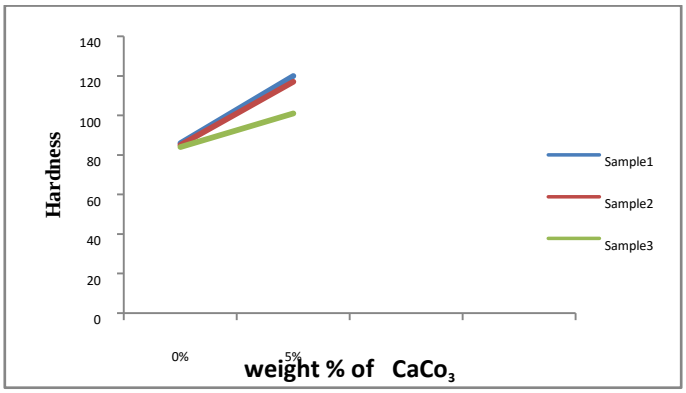


Figure 3 Relationships between Hardness of Nylon 66 with Composite

3.1.3. Elongation

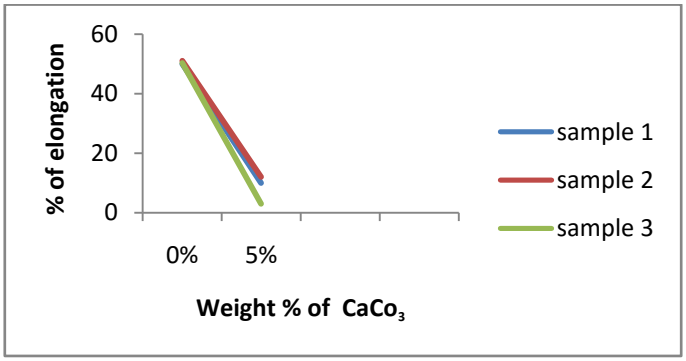


Figure 4 Relationship between elongation of Nylon 66 with Composite

Filler addition in Nylon 66 have adverse effect on elongation, Figure 4 shows that 5% adding of filler decrease its elongation from 50 % to 10% and increase of strength of Nylon 66 composite can lead to a great use to many automobile application.

IV. CONCLUSIONS

The prime objective of this distinct work was to prepare new composite material of Nylon 66 with $CaCO_3$ as filler, which was achieved and various tests were carried out. Test reports were analysed and it is found thatinNylon66 addition of 5% $CaCO_3$ increase its tensile strength upto 112MPa, reduceselongation by a high value i.e., 50% to10%, hardness also increases as elongation decreases.

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