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Preparation and Study of Nylon/CaSiO3 Composite

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***Abstract*—Nylon is made of repeating units linked by peptide bonds. Commercially, nylon polymer is made by reacting monomers which are either lactams, acid/amines or stoichiometric mixtures of diamines ($-NH_2$) and diacids (-COOH).. In this paper a anew composite of Nylon is prepared. Directly a standard specimen is prepared by Injection moulding. By adding wollastonite filler aiming in reduction of the elongation of Nylon. Wollastonite is an industrial mineral comprised chemically of calcium, silicon and oxygen. Its molecular formula is CaSiO3 and its theoretical composition consists of 48.28% CaO and 51.72% SiO2.**

***Objective:* The objective of the work is to reduce elongation of the nylon . Compounds is to be added to Nylon polymers to design composite materials with improved properties and to lower the overall production cost. In this investigation, the influence of adding inorganic mineral fillers on the mechanical properties of nylon is to be investigated.**

***Methodology/approach:* One or combination of more than one filler with different percentage by weight were added to nylon. Wollastonite with weight percentage varying between 5, 10 and 15 wt.% were added to nylon. Samples of the composites were prepared by injection molding process. Uniaxial tensile tests were carried out.**

***Results:* From testing elongation % of all sample were fined, test value shows for sample-1 i.e for 5% $CaSiO_3$ elongation is 8%, for sample-2 4% and for sample-3 5.5%. The results showed that the elongation of nylon composite decrease with the filler addition, while the weight ratio 5% and 10% but it is increasing when it is 15% then 10% addition. The maximum improvement is recorded with the addition of 10 wt.% filler ratio.**

***Research limitations/implications:* A correlation has been developed to predict the changes of properties with the addition of different ratio of filler material on the change in elongation.**

***Index Terms*— COOH, monomers, $-NH_2$, CaSiO3, Wollastonite, lactams.**

I. Introduction

Nylon is made of repeating units linked by peptide bonds. Commercially, nylon polymer is made by reacting monomers which are either lactams, acid/amines or stoichiometric mixtures of diamines ($-NH_2$) and diacids (-COOH). Mixtures of these can be polymerized together to make copolymers. Nylon polymers can be mixed with a wide variety of additives to achieve many different property variations. Nylon polymers have found significant commercial applications in fabric and fibers (apparel, flooring and rubber reinforcement), in shapes (molded parts for cars, electrical equipment, etc.), and in films (mostly for food packaging). Nylon was the first commercially successful synthetic thermoplastic polymer. The first example of nylon was produced using diamines by Wallace Hume Carothers at DuPont's research facility at the DuPont Experimental Station. In response to Carothers' work, Paul Schlack at IG Farben developed nylon 6, a different molecule based on caprolactam.

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Nylon is a generic designation for a family of synthetic polymers, based on aliphatic or semi-aromatic polyamides. Nylon is a thermoplastic silky material that can be melt-processed into fibers, films or shapes. Nylon was first used commercially in a nylon-bristled toothbrush in 1938, followed more famously in women's stockings or "nylons" which were shown at the 1939 New York World's Fair and first sold commercially in 1940. During World War II, almost all nylon production was diverted to the military for use in parachutes and parachute cord. Wartime uses of nylon and other plastics greatly increased the market for the new materials.

The properties of NYLON have been in studies over the years. Hence, polymers containing inorganic fillers have been studied widely because of its growing industrial applications. Now nylon is a well-known engineering thermoplastic polymer over the past decades. The Inorganic particulate fillers such as calcium carbonate, talc, mica, kaolin etc. of micrometer-sized particles are used to improve tensile strength, hardness, impact strength, toughness but in reduction of 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 tensile, impact and bending properties of $CaCO_3$ and hollow glass bead filled nylon 66 and reported that for the injection molded specimens the tensile modulus increases with increasing ratio of fillers and tensile strength decreases gently with the increase of filler.(Jiang et al. 2005) It is also found that micron-sized and nanosized $CaCO_3$ with nylon 66 and 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 and found 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 in the field of 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 taking various proportion of nylon 66/$CaCO_3$ the mechanical properties are analysed, try is made to improve mechanical properties and decrease the elongation % of nylon 66. A analyse is done between the theoretical properties of nylon 66 and the nylon 66 / $CaCO_3$ composite is done.

II. Experimental Details

A. Materials

The material for the experiment is nylon supplied by shree bajrang traders and thee filler selected is wollastonite supplied by Gulsan Polyol Ltd, Its molecular formula is CaSiO3 and its theoretical composition consists of 48.28% CaO and 51.72% SiO2.

B. Preparation Of Nylon

Nylon is made of repeating units linked by peptide bonds. Commercially, nylon polymer is made by reacting monomers which are either lactams, acid/amines or stoichiometric mixtures of diamines (-NH_2) and diacids (-COOH). Mixtures of these can be polymerized together to make copolymers. Nylon polymers can be mixed with a wide variety of additives to achieve many different property variations. Nylon polymers have found significant commercial applications in fabric and fibers (apparel, flooring and rubber reinforcement), in shapes (molded parts for cars, electrical equipment, etc.), and in films (mostly for food packaging).

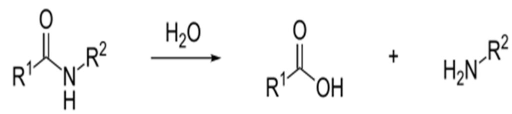

Figure.1. Structure of Nylon

C. Properties of Nylon

The properties of Nylon is given in table .1 The properties of Nylon 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	NYLON
Tensile strength	MPa	70
Tensile modulus	MPa	2900
Flexular modulus	MPa	1980
Elongation at break	%	65
Impact strength	J/m	45
Hardness		M70

D. 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 for 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. For each group of sample 3 specimens were tested, and the average values of the mechanical properties were determined from the measured data.

E. Sample Preparation

Taking weight % of 5,10 and 15 of CaSiO3 with , 950, 900 and 850gm of nylon is taken for the study , This three sample of Nylon is kept in to the heater setting temperature range 70 ^{0c} for 2.5 hr for drying to remove the moisture content whish help for melting ,then Nylon is mixed with CaSiO3 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 fig and figure.2.

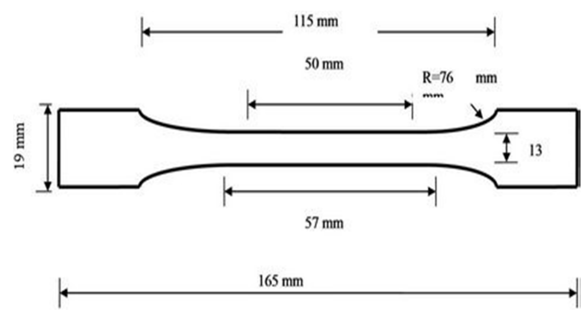

Figure 2. Standard specimen

F. Specimen Preparation

Standard size Specimen as shown in figur.2.1 is prepared by Injection moulding machine, CPR-M-29 moulding machine is used for moulding the specimen. Three number of specimen from each sample is prepared for testing.

III. TESTING

To know the elongation behaviour of the component elongation is carried out of the specimen prepared and are listed in the table in the Table.2: Three specimen for each sample are tested for different composition i.e for 5%, 10%, 15%.

TABLE II: TESTED VALUE OF NYLON COMPOSITE WITH CASIO3

SAMPLE	SPECIMEN	% of elongation
1) 5% CaSiO3		
	1	8
	2	7.9
	3	8.2
2) 10% CaSiO3	1	4
	2	4.1
	3	4
3) 15% CaSiO3	1	5.6
	2	5.5
	3	5.6

A. Results

Test were carried out for Nylon and its composite of 5%, 10% and 15% **$CaSiO_3$** in 1kg of Nylon the test results have shown that addition of filler in Nylon decrease its % of elongation great extent.

B. Tested Resultes For Sample-1

Tested value for sample-1 i.e for 5% $CaSiO_3$ is plotted in the Figure:3. three test were carried for each sample and all the test value shows that when we add 5% $CaSiO_3$ the elongation of the composite decrease to a great value, in test 1 elongation is decreasing to 8% where as at 0% $CaSiO_3$ elongation is 65% for Nylon, similarly for sample 2 value elongation % decreasing to 7.9% and for sample-3 8.1%. all the test shows that by adding 5% $CaSiO_3$ the value of elongation is decreasing.

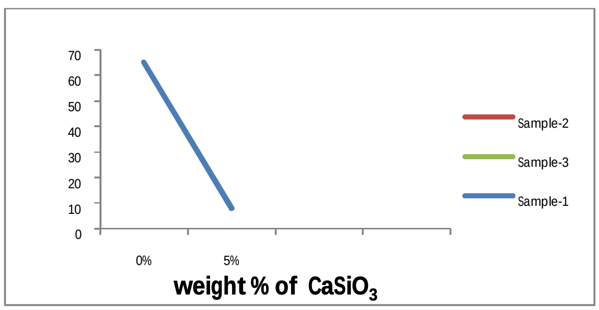

Figure:3. Relationship between Elongation of Nylon with 5% $CaSiO_3$ composite of Nylon for sample-1

C. Tested Results for Sample-2

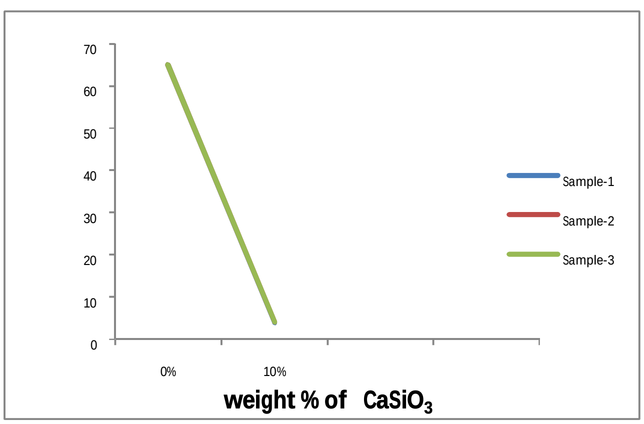

Figure:4. Relationship between Elongation of Nylon with 10% $CaSiO_3$ Nylon composite for sample-2

Figure 4. shows relation for pure Nylon with 10% $CaSiO_3$ addition , tested value for test-1 of sample-1 shows 10% $CaSiO_3$ addition decrease the elongation to 4% and for Sample-2 value is 4.1% for Sample-3 value is 4.1% . in all the cases the value of elongation decreasing as we can see from the graph.

D. Tested Results for Sample-2

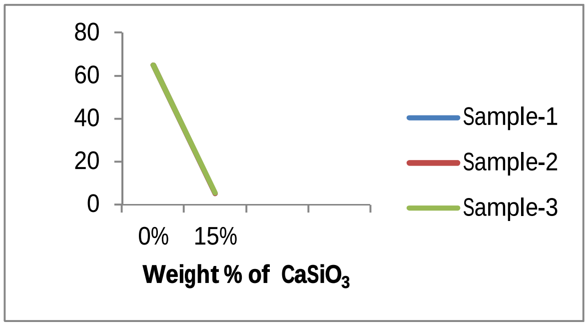

Figure:5. Relationship between Elongation of Nylon with 15% $CaSiO_3$ Nylon composite for sample-3

All the test value for sample are plotted in Figure:5. it shows that % elongation decreasing to 5.4%, in sample-2 5.5% and in sample-3 it is 5.6%, in all the sample the elongation value are decreasing. but value is increasing as compared to sample 2.

IV. Conclusions

The prime objective of this distinct work was to prepare new composite material of Nylon with CaSiO3 as a filler, which is achieved and test were carried out. Test report were analysed and it is found that in Nylon addition of 5% CaSiO3 decrease its elongation up to 8% where it was 65% in normal Nylon, in sample-2 it is decreasing to 4% and for sample-3 5.5% in all the cases elongation reduces to a high value, from the test as we see but for sample-3 value is increasing than the sample-2, so 10% addition of CaSiO3 will give the best value of reduction of elongation for Nylon.

References

[1] Vogler, H (2013). "Wettstreit um die Polyamidfasern". Chemie in unserer Zeit. 47: 263. doi:10.1002/ciuz.201390006.
[2] *Kohan j, Melvin (1995). Nylon Plastics Handbook. Munich: Carl Hanser Verlag.* ISBN 1569901899.
[3] Jump "Science of Plastics". *Chemical Heritage Foundation*. Retrieved 27 January 2015.
[4] Jiang, L., Lam, Y.C., Tam, K.C., Chua, T.H., Sim, G.W., Ang, L.S., 2005. Strengthening acrylonitrile-butadiene-styrene (ABS) with nano-sized and micron-sized calcium carbonate. Polymer Journal 46 243–252.
[5] Liang, J., 2005. Mechanical properties of hollow glass bead-filled ABS composites. Journal of Thermoplastics Composites Material 18, 407-416.
[6] Lin, Y., Gao, C., Li, N., 2006. Influence of $CaCO_3$ whisker content on mechanical and tribological properties of polyether-ketone composites. Journal of Material Science Technology 22, 584–588.
[7] Minitab User Manual., 2001. Making data analysis easier, MINITAB Inc., USA. Ozcelik, B., Sonat, I., 2009.
[8] Cho, M.H., Bahadur, S., 2005. Study of the tribological synergistic effects in nano CuO-filled and fiber-reinforced polyphenylene sulfide composites. Wear 258, 835–845.
[9] Cho, M.H., Bahadur, S., Pogosian, A.K., 2005. Friction and wear studies using Taguchi method on polyphenylene sulfide filled with a complex mixture of MoS2, Al2O3, and other compounds. Wear 258, 1825 – 35.
[10] Difallah, B., Kharrat, M., Dammak, M., Monteil, G., 2012. Mechanical and tribological response of ABS polymer matrix filled with graphite powder. Materials and Design 34, 782–787.
[11] Warpage and structural analysis of thin shell plastic in the plastic injection molding. Materials and Design 30, 367–375.
[12] Rashmi, N., Renukappa, M., Suresha, B., Devarajaiah, R.M., Shivakumar, K.N., 2011. Dry sliding wear behaviour of organo-modified montmorillonite filled epoxy nanocomposites using Taguchi's techniques. Materials and Design 32, 4528.