FLEXURAL PROPERTIES OF CALCIUM META SILICATE REINFORCED POLYAMIDES

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Abstract- **The present investigation was undertaken to find the reinforcing effect of Calcium meta silicate ($CaSiO_3$) on polyamides. Polyamide (NYLON6) was reinforced with varying percentage of $CaSiO_3$ of say 1%, 3% and 5% respectively. Samples were made by injection molding technique. The prepared samples were then subjected to three-point flexural test to determine the flexural properties. Flexural strength and flexural modulus of the reinforced polyamides were determined.**

The polyamides reinforced with 1% $CaSiO_3$ showed a good improvement in flexural strength when compared with 3% and 5% samples. The improvement in strength of 1% samples could be attributed to the fact that $CaSiO_3$ when less in content acts as a perfect reinforcing material but with the increase in $CaSiO_3$ percentage, the particles act as a source of imperfection and leads to the decrement in the strength of the samples.

Keywords: $CaSiO_3$, Polyamides, Nylon6, Flexure, Stiffness

I. INTRODUCTION

In recent times, the reinforcing and filling of plastics has gained much interest due to the increasing awareness in engineering plastics [6, 7]. But, in case of thermosets there is a distinct variation between reinforcing and filling, while it is more complex to make such a clear distinction where thermoplastics are concerned. On the other hand, it has to be noted that compounding, for thermoplastics, is a cost-increasing step in production, whereas for thermosets it does not usually affect production costs markedly. By using these additives it is possible to tailor the properties of the compounds to different end-use requirements by simultaneously affecting the mechanical, thermal and electrical properties [6, 7].

For thermoplastics a great variety of materials have been tried. Probably most powders which can be subdivided have been tested. These additives can be classified in many ways, e.g. organic/inorganic, synthetic/natural, according to size and shape, etc. At present glass fibre, in different forms, mica, talc, wollastonite are probably those which are most frequently used in thermoplastics. In addition, certain groups of additives such as carbon, aramid and synthetic ceramic fibres are of great technical importance, although they are used in smaller quantities [1, 4].

Wollastonite also know as Calcium silicate or Calcium meta silicate is commonly used functional filler in thermoplastics, particularly in polyamides and polypropylene, because it is available in grades with very fine particle size and in grades with high aspect ratio, containing acicular or needle-like particles [3]. Wollastonite is a naturally-occurring industrial mineral whose main chemical composition consists of calcium, silicon, and oxygen. The molecular formula for wollastonite is $CaSiO_3$ and its theoretical composition consists of 48.3 % CaO and 51.7% SiO_2. The mineral has several characteristics that make it commercially valuable, including its high brightness and whiteness, its low moisture and oil absorption properties, and its low volatile content. Because of these attributes, wollastonite is presently used in a variety of industrial applications, including ceramics, friction products, metallurgy, paint filler, and plastics [2].

Nylons are among the most widely used engineering thermoplastics in automobile, electrical, electronic, packaging, textiles and consumer applications because of their excellent mechanical properties. However, limitations in mechanical properties, such as low heat deflection temperature, high water absorption and dimension instability of pure nylons have prevented their application in structural components. Hence numerous efforts have been undertaken to use nylons as matrix resins in composites by adding inorganic fillers such as aluminatrihydrate, montmorrilonite, clays, talc, mica, silica, flyash, wollastonite, kaolin [8].

In this investigation $CaSiO_3$ of variable percentage was added to nylon-6. Influences of the addition of these fillers on the flexural properties were examined.

II. EXPERIMENTAL PLAN

The Schematic representation of experimental plan is shown in the following fig. 1:

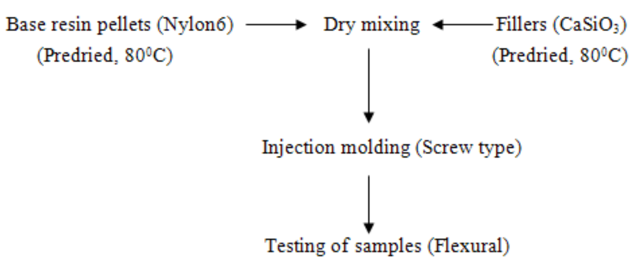

Fig. 1: Experimental plan

A. Injection molding

The granules of the nylon6 and $CaSiO_3$ were pre-dried in an air circulated oven at 80^0C for 8 hours and injection molded in a screw type injection molding machine fitted with a master mould containing the cavity for flexural specimens. After its ejection from the mould, specimens were air dried for a few minutes. The injection molding was carried at Shrinidhi Plastics*****, Bangalore.

B. Flexural Testing

The flexural properties were determined in 3-point bending. At least five rectangular beam specimens for each composition were tested according to ASTM D790. The test specimens were of 127mm X 12.7mm X 6.4mm dimensions. Tests were conducted at ambient temperature, using a flexural testing machine. Specimens were centre loaded in 3-point bending as a simply supported beam. The distance between the spans was 100 mm [5]. Flexural modulus of each sample was determined from the average value of five specimens. Figs. 2 and 3 show the mold and flexural testing machine used in the study. The flexural strength, strain and flexural modulus were calculated using the equations 1 – 3.

Calculation of flexural strength

$$\sigma = \frac{3FL}{2bd^2} \qquad (1)$$

Calculation of flexural strain

$$\epsilon_f = \frac{6Dd}{L^2} \qquad (2)$$

Calculation of flexural modulus

$$E_f = \frac{L^3 m}{4bd^3} \qquad (3)$$

Where,

- F is the load (force) at the fracture point (N)
- L is the length of the support span (mm)
- b is width (mm)
- d is thickness (mm)
- m is the gradient of the initial straight-line portion of the load deflection curve (N/mm)

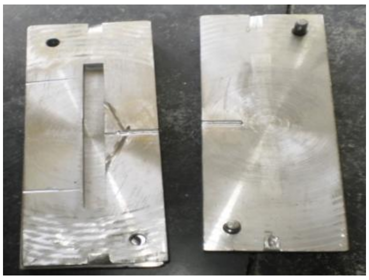

Fig. 2: Mold for preparing flexure samples

Fig. 3: Flexural testing machine

III. RESULTS AND DISCUSSIONS

The effects of $CaSiO_3$ reinforcement on the flexural modulus of N6/$CaSiO_3$ composites are presented in Figs. 5 – 7. The incorporation of 1% $CaSiO_3$ into the matrix of Nylon6 increases the stiffness of the N6/$CaSiO_3$ composites. The flexural modulus of Nylon6 is 18.458 GPa and that of 1% reinforced nylon6 is 21.972 GPa, which is an increase of 16%. The improvement in modulus could also be attributed to the high aspect ratio, contact surface and reinforcing effects of $CaSiO_3$. According to Pentti Jarvela, et al. [6], the stiffness of the composite increased with the addition of $CaSiO_3$. An improvement in tensile strength of 10 to 15% was observed. Also, it was observed that the elongation at fracture decreases to about 1/20 of that of pure matrix material.

At higher percentages of $CaSiO_3$ it is seen that $CaSiO_3$ weakens the flexural strength of the material, but at the same time it makes the material more flexible and this can been seen for 5% reinforcement from the table. The possible reason for decrease in the flexural strength and the flexural modulus is due to the poisoning effect of $CaSiO_3$. At higher percentages the particles of $CaSiO_3$ acts as the sites of imperfections, thus decreasing the strength. The poisoning effect of $CaSiO_3$ could be a boon for applications which need materials to be flexible. The Table I also shows that material transforms from brittle to ductile at 5% reinforcement.

TABLE I

Flexural Test values of Nylon6 and its composites

Specimens	Maximum Flexural Stress, (MPa)	Maximum %strain	Flexural Modulus, (GPa)
Nylon6	45.1	7.8	18.458
Nylon6 + 1% $CaSiO_3$	76.3	5.34	21.972
Nylon6 + 3% $CaSiO_3$	42.32	6.1	23.072
Nylon6 + 5% $CaSiO_3$	27.3	17.9	5.695

IV. CONCLUSIONS

The Nylon6 reinforced with varying percentages of $CaSiO_3$ were tested under flexural loading with the following conclusions:

- The incorporation of 1% $CaSiO_3$ into the matrix of Nylon6 increases the stiffness of the N6/$CaSiO_3$ composites.
- At higher percentages of $CaSiO_3$, decrease in flexural strength can be observed.
- At 5% reinforcement material losses its stiffness and transforms into a flexible material.

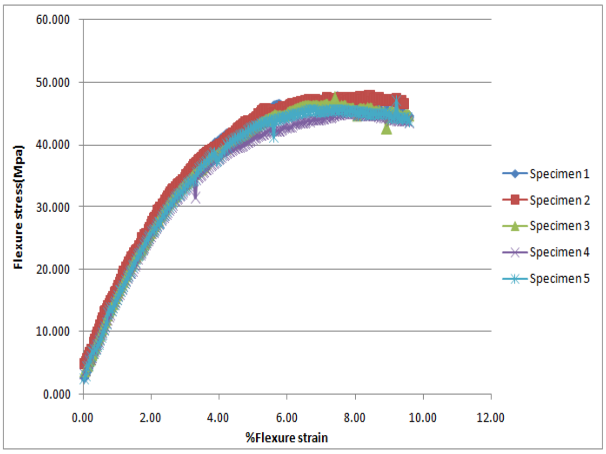

Fig. 4: Nylon6 Samples

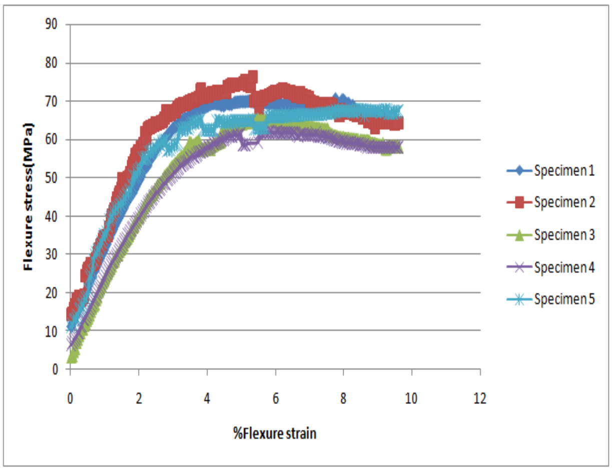

Fig. 5: Nylon6 + 1% $CaSiO_3$ Samples

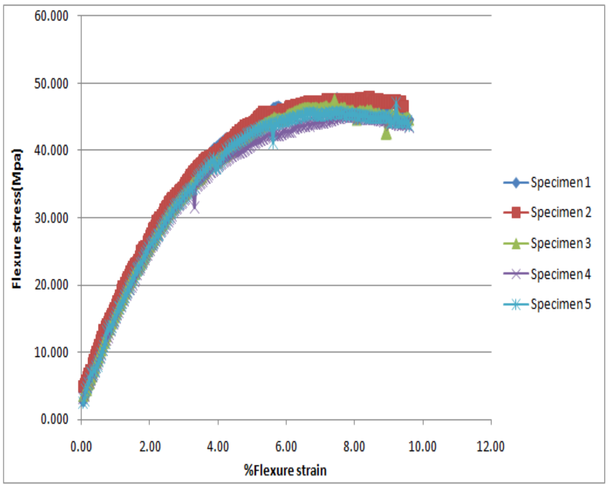

Fig. 6: Nylon6 + 3% $CaSiO_3$ Samples

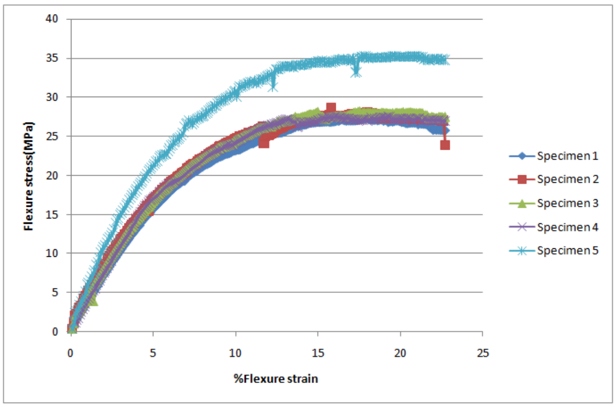

Fig. 7: Nylon6 + 5% $CaSiO_3$ Samples

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