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Fabrication and Characterization of PPS /40%GF/nano-$CaCo_3$ Hybrid Composites

Y.Haribabu[1], K. Ajay sir[2], B. ravikiran[3]
*(Mechanical department, M.V.G.R college of engineering, JNTU, INDIA)
** (Mechanical department, M.V.G.R college of engineering, JNTU, INDIA)
*** (Mechanical department, T.P.I.S.T college of engineering, JNTU, INDIA)

ABSTRACT: *In the present work fabrication of composite material(PPS+40%GF+NANO $CaCO_3$) was carried out and their tensile properties viz tensile strength, tensile strain(%),young's modulus, energy at maximum load and brinell hardness number were found and surface morphology of tensile fracture was analyzed by using SEM and EDS. Specimens of Polyphenylene sulfide (PPS)/Glass Fiber(GF) hybrid composites are prepared with four different compositions of nano-calcium carbonate($CaCO_3$), viz., 0,3,5 and 7%.Each specimen consisting of 40%GF.The specimens are fabricated by using micro-compounder with micro injection molding machine. Tests are conducted on these specimens to determine the tensile strength, tensile strain, young's modulus energy at maximum load and hardness number at room temperature using universal testing machine and Brinell hardness testing machine. The influence of the nano-$CaCO_3$ content on the mechanical properties tensile of hybrid composites was studied. Surface morphology of tensile fracture of the hybrid composites is analyzed by using Scanning electron Microscope (SEM).Point chemical analysis of the hybrid composites is analyzed by Energy Dispersive Spectrum (EDS).Thus it gives the various inorganic elements present at a particular location. It is found that the reinforcing and toughening effects of the PPS/GF hybrid composites are increased by adding nano-$CaCO_3$.The tensile strength, tensile strain, young's modulus and energy at max load of these composites increased nonlinearly with the addition of the nano-$CaCO_3$.*

Keywords: hybrid composites, PPS, GF Nano-$CaCo_3$, Tensile properties, hardness test, SEM, EDS

I. INTRDUCTION

Polyphenylene sulphide (PPS) composites are widely used especially in automotive main parts due to their easy process ability most automotive parts (especially the outer parts, like sun-roof, etc.) would either be exposed to natural weathering or to more extreme environments. It is an engineering thermoplastics, It possesses high temperature resistance, excellent electrical and mechanical properties.PPS has been widely used in corrosion resistant coating, mechanical parts, electric and electronic apparatus. PPS has a glass transition temperature of 80–90^{o}C and melting temperature of 280^{0}C. PPS has good dimensional stability, high strength, high modulus, chemical and fatigue resistance, and can be metal substitute engineering plastic. In electronics, PPS is typically found in connectors, plug boards, coil formers, relays, switches and chip carriers. Glass fiber is a material consisting of numerous extremely fine fibers of glass. Glassmakers throughout history have experimented with glass fibers, but mass manufacture of glass fiber was only made possible with the invention of finer machine tooling. Various researchers have investigated the effect of nano-inclusions on various polymers and also discussed the properties of Polyphenylene sulfide and other polymers. The influence of adding Nano-inclusions,to the polymers are studied. The comprehension of technical papers is given. Liang et al.[1] studied the how the mechanical properties such as tensile modulus, yield strength, and impact strength effect by add of the glass beads to polypropylene matrix. Impact strength of this composite has enhanced by 1.4 times of the unfilled polypropylene. Impact tests of notched specimens were also conduct at room temperature according to the ASTM D256.Morphology studies are also done by using SEM of unfilled polypropylene cross-section. Yang et al.[2] discussed application Poly (1,4-phenylene-sulfide) PPS is a special kind of engineering plastic with heat resistance, high mechanical strength, excellent chemical resistance, good electronic properties and good radiation resistance so widely used in many areas, especially in electronics, mechanical engineering ,chemical and petroleum industry and food industry. At present most PPS products are reinforced composites and polymer alloys like Ryton-PPS is a 40%Glass fiber reinforced composites Yanga et al.[3] studied The effect of surface treatment of glass beads with a silane coupling agent and the filler content on the notched IZOD Impact properties of the filled polypropylene (PP) composites has been investigated .It was found that the impact fracture energy of the composites increased with increasing the volume of the glass blends(wt%).The influence of surface treatment of the glass blends on was insignificant. Zhaobin et al.[4]The mechanical and tribological properties of carbon fiber (CF) reinforced polyamide 66 (PA66)/Polyphenylene sulfide (PPS) blend composite were studied in this. It was found that CF reinforcement greatly increases the mechanical properties of PA66/PPS blend. Impact strength(KJ/m^2) are observed as decreasing and increasing phenomenon.

II . EXPERIMENTAL ANALYSIS

Raw material: Polyphenylene sulphide with 40%GF was supplied by RK polymers, Mumbai, India. The melting temperature and density of PPS with 40%GF are 285^{0}C and 1600kg/m^3 respectively. The Nano-$CaCO_3$ was produced by Anyuan technical Industrial Co .Ltd, Jiangxi, and China. Mean diameter and density of the nano-particles are 80nm and 2500kg/m^3 respectively.

Preparation of test specimens: PPS with 40%GF are pre-dried for 3hours at 110-120^{0}C and nano-$CaCO_3$ particles pre-dried for 2hours at 80^{0}C in vacuum oven. The nano-$CaCO_3$ particles are mixed with the PPS and the glass fibre according to designated blending ratios .In this work ,the weight fraction of the glass fibre fixed as 40% and the weight fraction of the nano-$CaCO_3$ are 3%,5% and 7% and then the PPS/GF/nano-$CaCO_3$ blends are extruded in micro-compounder. These specimens are prepared as per the ASTMD638 STANDARD by Injection molding the specifications of specimens are 132x20x3.2mm^3

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Fig: Tensile specimen As per ASTM D638

Instrument and Methodology: The tensile properties of PPS/GF/Nano-$CaCO_3$ hybrid composites are measured at room temperature by means of universal testing machine with extensometer (INSTRON, 3382) .Tests were conducted according to ASTM D638 standard with cross-head descending speed of 2mm/min. The various properties are found from the experiment are tensile strength, tensile elongation at break point, young's modulus energy at maximum load. The mean values of polymer nano composites have been noted. The hardness test of the PPS /GF/nano-$CaCO_3$ Ternary composites were measured at room temperature by means of a Brinell hardness testing machine. Hardness test is conducted according to ASTM E 10. All Brinell tests use a carbide ball indenter.

Fig: Tensile test specimen dies as per ASTM D638

Fig: Universal testing machine (UTM)

III. RESULTS AND DISCUSSION

This table shows the mean values of max load, tensile strength, tensile strain, young's modulus and energy at maximum load at different specimen labels.

S.NO	Specimen label s	Mean value Maximum Load (N)	Mean Tensile strength (MPa)	Mean Tensile strain at Break (%)	Mean value of Youngs Modulus (MPa)	Mean value of Energy at Maximum Load (J)
1	PPS+40%GF+0%NC	5904.058	134.287	3.8264	4091.106	10.90365
2	PPS+40%GF+3%NC	5629.149	146.087	4.0406	5666.22	12.43635
3	PPS+40%GF+5%NC	5789.238	145.1254	3.9386	4572.67	12.03635
4	PPS+40%GF+7%NC	5629.218	145.687	3.8664	4572.67	11.77555

1. Tensile strength: Fig 1.1 shows the dependence of the tensile strength of the PPS/ GF/ nano-$CaCO_3$ composites on the weight fraction of nano-$CaCO_3$ ($Ø_f$) particles. The value of tensile strength increased with the increase of addition of weight fraction of nano-$CaCO_3$ particles to the matrix PPS/40%GF.The graph varies non-linearly from base composite to the PPS/40%/7%nano-$CaCO_3$ Hybrid composite .The maximum increase of tensile strength observed when the addition of 3% of nano-$CaCO_3$ particles to matrix this increase observed as 8 compared to the base composite i.e. PPS/40%GF/nano-$CaCO_3$.

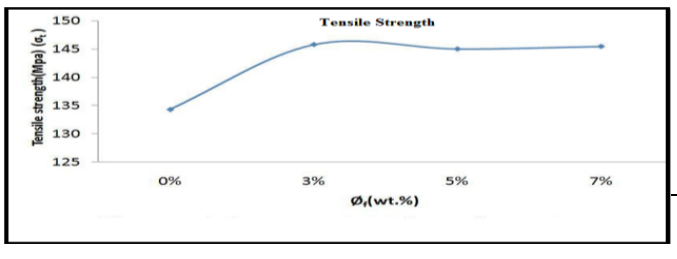


Fig 1.1: Effect of weight fraction of Nano-$CaCO_3$ ($Ø_f$) on tensile strength (σ_t)

2. Tensile strain: Fig 1.2 shows the dependence of the tensile strain of the PPS/GF/ Nano-$CaCO_3$ composites on the weight fraction of Nano-$CaCO_3$ particles.It can be seen that tensile strain increased non linearly with the addition of weight fraction of nano- $CaCO_3$.It means that the tensile strain of the PPS/GF binary composite materials filled with the increasing nano-$CaCO_3$ concentration will be enhanced effectively. The Max increase of the tensile strain ($€_t$) is observed at $Ø_f$ =3% is 5.59% as compared to the weight fraction of nano-$CaCO_3$ at $Ø_f$ = 0%.

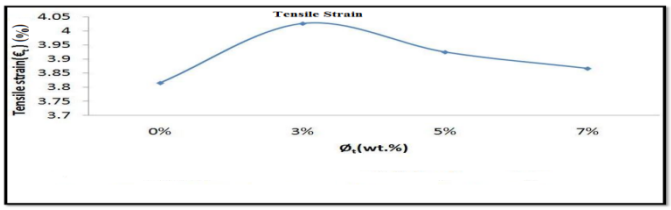


Fig 1.2: Effect of weight fraction of Nano-$CaCO_3$ ($Ø_f$) on Tensile Strain ($€_t$)

3. Young's modulus: Young's modulus is one major parameter for characterizing the tensile fracture toughness of materials.Fig 1.3 shows the effect of the weight fraction of the distribution of the particles in the matrix and the interfacial morphology between them are improved better. Consequently, the tensile fracture toughness of the PPS/GF/nano-$CaCO_3$ hybrid composite was enhanced correspondingly. The maximum increase of the young's modulus (E_t) at $Ø_f$ =3% is 11.77% as compared to the weight fraction of nano-$CaCO_3$ at 0%.Here the young's modulus (E_t) increased non linearly up to $Ø_f$ =3% , with the addition of wt. fraction of nano-$CaCO_3$ particles then decreases up to $Ø_f$ =5% then slightly decreases up to $Ø_f$ =7%.

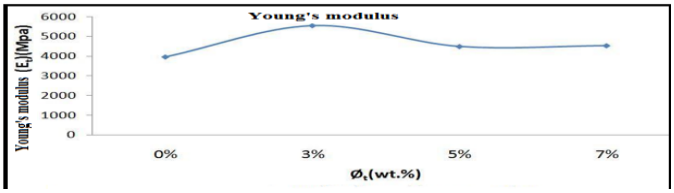


Fig 1.3: Effect of weight fraction of Nano-$CaCO_3$ ($Ø_f$) on young's modulus (E_t)

4. Energy at Maximum Load: Fig 1.4 shows the dependence of the energy at maximum load of the PPS/GF/ Nano-$CaCO_3$ composites on the weight fraction of Nano-$CaCO_3$ particles. It can be seen that the maximum increase of energy at maximum load(σ_E) is observed at $Ø_f$ =3% is3.24% compared to the weight fraction of nano-$CaCO_3$ at 0%. Here the energy at maximum load (σ_E) increased nonlinearly up to $Ø_f$ =3%, with the addition of wt. fraction of nano-$CaCO_3$ particles then gradually decreases up to $Ø_f$ =7%.

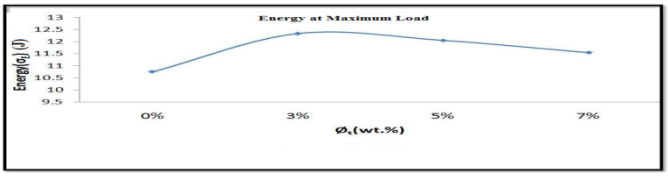


Fig:1.4 Effect of weight fraction of Nano-$CaCO_3$ ($Ø_f$) on Energy(σ_E)

5. Hardness test results: Hardness is extensively used to characterize materials and to determine if they are suitable for their intended use. The most common uses for hardness tests is to verify the heat treatment of a part and to determine if a material has the properties necessary for its intended use.It can be seen that the maximum increase of hardness number is observed at $Ø_f$ =5% is3.14% compared to the weight fraction of nano-$CaCO_3$ at 0%. Here the hardness number increased up to $Ø_f$ =5%. With the addition of wt. fraction of nano-$CaCO_3$ particles then gradually decreases at $Ø_f$ =7%.

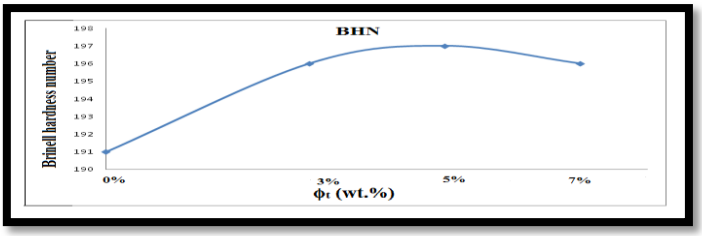


Fig.4.9 Effect of weight fraction of Nano-$CaCO_3$ ($Ø_f$) on Brinell hardness number (BHN)

IV. SURFACE MORPHOLOGY BY USING SCANNING ELECTRON MICROSCOPE (SEM)

1. SEM (scanning electron microscope): SEM photo graphs shows facture due to tensile load .These are shows surface morphology of the of polymer nano composites. I.e. how the nano particles distributed with increase of %wt. blending with PPS with 40%GF. And also seen, with an increasing loading of nano-$CaCO_3$, the nano particles could not be evenly distributed and form agglomerates. The SEM photo graphs can be shown as follows from figures 4.10 through 4.13.

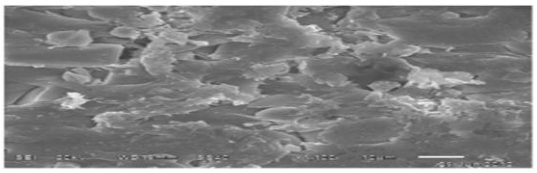


Fig 4.10 SEM: PPS/40%GF/0% nano-$CaCO_3$

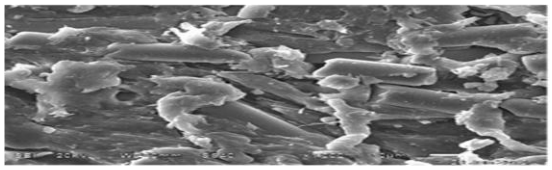


Fig 4.11 SEM: PPS/40%GF/3% nano-$CaCO_3$

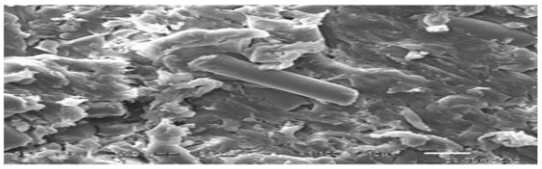


Fig 4.12 SEM: PPS/40%GF/5% nano-$CaCO_3$

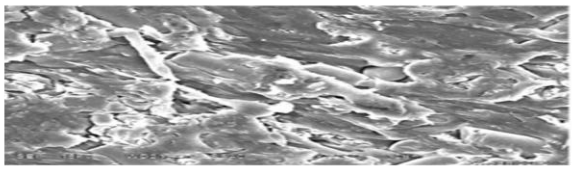


Fig 4.13 SEM: PPS/40%GF/7% nano-$CaCO_3$

2. Energy dispersive spectrum (EDS): This gives the chemical analysis of the composite materials and it also gives the various inorganic particles at a particular point in a composite material. The results of the EDS for Polymer nano composite material at various percentages of Nano-$CaCo_3$ Can be shown as follows from figures 4.14 through 4.17 and % of inorganic elements can also be in tables from 4.14 through 4.17 for each percentage of nano polymer composite .

Fig4.14 EDS: PPS/40%GF/0% nano-$CaCO_3$

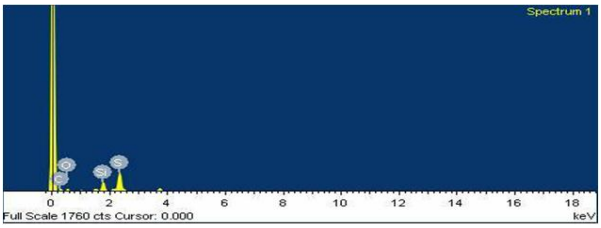


Fig4.15 EDS: PPS/40%GF/3% nano-$CaCO_3$

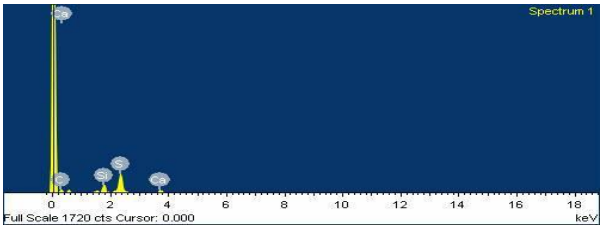


Fig4.16 EDS : PPS/40%GF/5% nano-$CaCO_3$

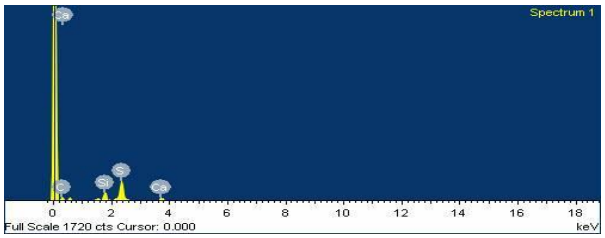
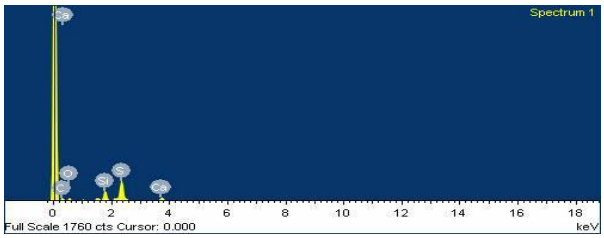


Fig4.17 EDS : PPS/40%GF/7% nano-$CaCO_3$



V. CONCLUSIONS

The following conclusions are dragged from the experimental investigations

[1] Reinforcing and toughening effects were found on PPS/GF/ nano-$CaCO_3$ composite materials.

[2] It was found that when the weight fraction of the nano particles was equal to 3%, the tensile strength and young's modulus and tensile strain were increased non linearly with the weight fraction of nano-$CaCO_3$ ($Ø_f$).

[3] The maximum increase of tensile strength observed when the addition of 3% of nano-$CaCO_3$ particles to matrix this increase observed as 8.78% compared to the base composite i.e., PPS/40%GF/nano-$CaCO_3$.

[4] The maximum increase of the tensile strain ($€_t$) is observed at $Ø_f$ =3% is 5.59% compared to the weight fraction of nano-$CaCo_3$ at $Ø_f$ = 0%.

[5] The maximum increase of the Young's Modulus (E_t) at $Ø_f$ =3% is 11.77% compared with the weight fraction of nano-$CaCO_3$ at 0%.Here the Young's Modulus (E_t) has been increased non linearly up to $Ø_f$ =3% with the addition of weight fraction of nano-$CaCO_3$ particles then decreases up to $Ø_f$ =5% then slightly decreases up to $Ø_f$ =7%.

[6] The energy at maximum load (σ_E) is increased non linearly up to $Ø_f$=3%, with the addition of weight fraction of nano-$CaCO_3$ particles then gradually decreases up to $Ø_f$ =7%

[7] It can be seen that the maximum increase of hardness number is observed at $Ø_f$ =5% is3.14% compared to the weight fraction of nano-$CaCO_3$ at 0%. Here the hardness number increased up to $Ø_f$ =5%, with the addition of wt. fraction of nano-$CaCO_3$ particles then gradually decreases at $Ø_f$ =7%.

[8] The mechanical properties of tensile strength, tensile strain and young's modulus at 3% and hardness at 5% showed that there was a good interfacial adhesion between the nano-$CaCO_3$ and the PPS matrix.

[9] SEM shows the surface morphology of the specimens with increase of load distribution of nano particles is un-even distributed and then agglomerated.

[10] From Energy Dispersive spectrum (EDS) it was found various inorganic elements present at a particular location in the specimen.

VI. ACHNOLOGEMENTS

I would like to tank for CIPET, Bhubaneswar, for providing fabrication and experimental facilities.

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