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## Blending of MWCNT/PP Composite Materials for Automotive Applications

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**ABSTRACT:** A masterbatch of polypropylene, multi-walled carbon nanotube composites was prepared via a kneader machine. Then they were mixed with aPP blend using a twin-screw extruder. A scrap grinderwas used to prepare the polymer strands in the twin screw extruder usingpallets. Morphological and sorption studies were conducted for the blended mixture of polypropylene and MWCNT, as well as tensile properties. Adding MWCNTs enhanced PP's elastic modulus and yield stress, while polymer strain at break drastically increased below percolation, followed by a decrease above percolation. MWCNTs were not oriented for chain alignment beyond percolation threshold concentrations, and MWCNTs that enhanced PP therefore failed before necking in tensile tests; the addition of MWCNTs generated the transition from pure uniaxial deformation behaviour in unfilled PP to an axisymmetric strain through-thickness after about 0.5 wt% % filler loading. The FTIR studies were used to identify the functional group of alkanes bonding in the base matrix. The mechanical properties of blend composites show a significant increase in modulus of elasticity when compared with pure PP. The morphological properties depict the dispersion of carbon nanotubes in PP. This blend of composites can be used for automotive applications such as vibration dampers.

KEYWORDS: PP, MWCNT, Injection molding, extrusion molding

#### I. LITERATURE SURVEY

Commodity plastics such as PP and carbon nanotubes are combined to form a blending mixture. Polypropylene (PP) is generally immiscible because smaller differences in the shape of the molecules overcome the weak intermolecular forces. Compatibility in blends of immiscible homogenous polymers is an interfacial phenomenon. Polypropylene frequently utilizes homogeneous and miscible blends at the homogeneous blend level [1]. The blending of polypropylene and CNT can be done using an internal mixer machine. The polymer and filler can be blended by interfacial adhesion[2]. The compatibilization process is a multiplicity of strategies designed to do just that. The compatibilizers can enhance the blend properties [3,4,5]. Mechanical properties: CNT may be used to enhance polymers [6]. A compatibilizer can be compatible with numerous commercially available polymer blends on the market [7]. Dipole-dipole and hydrogen bonding are two illustrative nonbonded interactions that polymers with polar groups could have towards the components in solution [8]. Maleic anhydride is used as the compatibilizer.





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blend cross-linking is enhanced by the compatibilizer maleic anhydride grafted into polyethylene. Polypropylene - It is an exceptionally affordable polymer that can be easily processed and has high mechanical properties along with good recyclability. In addition, these polymers have higher toughness and improved flexibility when they are blended [9]. Super tough polymers, as opposed to normal polymers or polymer blends, are favored for sophisticated applications. There are several known studies on mixes based on PP.Carbon nanotubes (CNTs), with their high aspect ratio, low density, excellent mechanical strength, and high thermal and electrical conductivities, have been effectively used as a filler in polymer composites [10]. Polymer materials, with their low weight and reasonably priced nature, have also found extensive use. They do not, however, have the same electrical and thermal conductivities or mechanical properties as metals. As a result, efforts to enhance the characteristics of polymers by incorporating MWCNTs have been continuously undertaken over time [11].Many domains have investigated a polymer composite with MWCNTs added as a filler, especially for mechanical, thermal, and electrical applications [12]. Adding MWCNTs can significantly increase a polymer's strength and fracture resistance because polymers typically have poor mechanical properties [13]. A polymer's thermal conductivity is generally less than 1 W/m K and has a very short phonon mean free path [14]. Therefore, by adding thermally conductive MWCNTs, a heat conduction path can be created, improving the heat radiation performance of the material. Similarly, the high electrical conductivity of MWCNTs can be used to create an electrical path within a polymer. The percolation threshold is reached when a specific concentration of MWCNTs is evenly distributed throughout a polymer because the MWCNTs are sufficiently close together to allow for the possibility of electron flow through the tunnelling effect [15]. The effects of MWCNT on the properties of composites have been the subject of extensive research on MWCNT-incorporated polymer composites. Since the multiphase properties of a polymer blend rely on both the microstructure of the blend and the two polymers, controlling the microstructure is crucial to determining its properties [16]. The polymer matrix and the amphiphilic material work together to lessen the material's rigidity[17-208].

#### **II. METHODOLOGY**

PP is the material used in this production process, and they are purchased from Reliance Industries Ltd. Saver Matrix Nano Pvt Ltd is a polypropylene-grafted maleic anhydride and multi-walled carbon nanotube company. PP has a density of 0.92 g/cm<sup>3</sup>, a melting point of 171<sup>o</sup>C, and a melt flow index of 25 g/10 min at 190<sup>o</sup>C. The PP polymer blends with pEMAH and CNT filler are mixed using a twin-screw extruder. The master batch was prepared using 1.5wt% and 3wt% of CNT. The material is placed in the hopper and mixed in the barrel unit, which has an extruder screw while maintaining the proper melting temperatures. The screw rotates at a speed of 100 rpm and the temperature along the extruder's barrel from the feed-to-die zone range from 150 to 210 <sup>o</sup>C.Pellets are created from the polymer strands using a scrap grinder machine. A Ferromatik Milacron Sigma 50T injection molding machine is used to inject these polymer pellets. According to ASTM D-638 and ASTM D-256, the injection moulding machine creates dumbbell-shaped tensile and impact specimens. The machine's processing temperature ranges from 180 to 210 <sup>o</sup>C, while the mold is kept at 50 <sup>o</sup>C.



#### Fig 1. Processing method of blending PP/MWCNT





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#### 1.1 Processing Conditions:

The barrel unit of The four temperature zones of the injection unit's barrel unit are kept at 280°C, 260°C, 240°C, and 220°C. 12 seconds is the injection time; 2 seconds is the packing time; 3 seconds is the holding time; 38 seconds is the cooling time; 50 seconds is the extruder delay time; 2 seconds is the clamp open dwell; 38 bar is the back pressure; 20 bar is the hold-on pressure; 30 millimeters is the ejector forward speed; 55 mm is the ejector forward limit; 1 second is the ejector dwell timer; 80 mm is the ejector retract speed; 1 sec is the ejector pulse; 137.4 millimeters is the actual clamp position; 18.3 millimeters is the actual ejector position. The clamp has the following characteristics: its fast speed of 80 mm/sec; its close slow-down position of 50 mm; its moldprotect pressure of 50 mm; its mold protect timer of 40 mm/sec; its mold touch position of 30 bars; its open fast position of 30 mm; its open fast speed of 20 bar; its open slow-down position of 4 sec; and its open limit of 135 mm.

#### 1.2 Analysis of Injection Molding

The analysis for that study was conducted using Moldex 3D software. The type of mesh utilized was "Midplane Mesh". The location of the gate was established through the analysis of optimal gate placement using Moldex 3D. The cooling system was determined not to be among the most effective factors; the values associated with the cooling system were utilized as default values (injection molding machine and mold material: tool steel P20) from the Moldex 3D software, which was treated as the cooling system. The analysis conducted in Moldex 3D encompasses Cool+Flow+Warp. Warpage analysis can be conducted in the X, Y, and Z directions.



#### Fig 2. Filling analysis of rear brake shoe

#### **III. EXPERIMENTAL RESULTS**

#### 1.2. FTIR analysis

Fourier-transform infrared spectroscopy (FTIR) analysis may be used to observe a material's infrared spectrum of absorption or emission. FTIR collects high-resolution spectral data over a broad spectral range. It displays how much of a single wavelength of infrared light a sample absorbs at each wavelength. Their FTIR spectra reveal the compositions of solids, liquids, and gases. The most common applications are for material identification (for example, unknown materials) and industrial material verification. The idea that radiation interference between the two beams results in an interferogram is the basis of FTIR spectroscopy. The latter is a signal that is produced when two beams are reflected off different mirrors and their paths deviate by a certain amount. Wave numbers, which typically range from 4000 to 600 cm-1, are used to measure frequency ranges. This technique obtains an infrared spectrum of the absorption or emission from a solid, liquid, or gas. KBr pellets in the 500–4000 cm-1 range are used with the Bruker Scientific FTIR Nicolet

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iS10 instrument to investigate the spectrum characteristics of polymer mixtures. The FTIR spectra of the polymer blends made in Runs E, EC1, and EC2 are displayed in the figure. The Table lists the functional group that corresponds to each peak in the FTIR spectrum characteristics for the polymer blends made in Runs E, EC1, and EC2. An FTIR is used to analyze the chemical structures of PP polyblends. The terms 2965 relateto CH<sub>2</sub> asymmetric stretching bonding, 1652 all relate to C=C stretching, whereas the terms 1456 pertain to CH<sub>2</sub> bending.





#### **1.3 Mechanical Properties**

Tensile strength is the maximum load that a material can withstand when put under tension. It is acceptable to use the phrases yield, ultimate, and fracture (breaking) strength. These values are determined through the use of uniaxial tensile testing. This test enables the plotting of stress-strain curves that depict a material's response to tension-loaded loads. Polymer blends' elastic modulus and tensile stress are measured using universal testing equipment. Tensile tests are utilized to determine the strength properties of new material compositions. It is used to verify that a sizable quantity of material meets its initial specifications or to assess the results of heat treatments or other processes. Verifying the quality of incoming raw materials is a crucial step in maintaining process control and averting errors. The numbers for Young modulus are obtained from the slope of the tensile curves, whilst the tensile strength data were obtained directly from testing on the universal testing machine. According to ASTM D638-14 (ASTM D638 et al.), a Tinius Olsen H25KT (Tinius Olsen, UK) is used to measure the tensile strength of the PP mix. The samples are produced according to ASTM D638 Type IV. Five samples of each specification are acquired, with the test speed being 50 mm/min and the spacing between the two clamps being 25 mm. The tensile strength and elastic modulus of polymer blends are compared in the table. Young's moduli are 2.5 MPa, 2.699 MPa, and 2.74 MPa for pure PP, blended 1.5%, and 3% MWCNT.



Fig 3. Stress-Strain Curve for PP-MWCNT





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#### **1.4 Morphology Properties**

The form and dispersion of MWCNT in the polymer matrix were observed by analyzing SEM images of PP and PP-MWCNT containing 1% and 2% MWCNT. SEM analysis was used to look at the polymer mixes' surface morphology. The SEM micrographs show the MWCNT dispersion in the PP. The PP blend's 10 µm and 20 µm resolution SEM images are shown in Figures 1(a) and (b), respectively. The SEM images of PP/MWCNT with 10 µm and 20 µm resolution, respectively, are displayed in Figures 1(c), (d), (e), and (f). In the case of the PP/MWCNT blend, MWCNT disperses inside the inhomogeneous shape that PP forms as the matrix. Since MWCNT has a lower viscosity than PP, segment separation results in this scattered portion. The SEM pictures for the PP/MWCNT mix demonstrate a well-dispersed CNT that enhances the overall shape. The compatibility between PP and MWCNT seems to be improved by the presence of MWCNT, which lessens section separation. There is an improvement in the adhesion between MWCNT and PP. As a result, the mixture exhibits a uniform structure. The MWCNT has a fibrous or net-like shape and is evenly distributed throughout the PPbase matrix.



(a)PP with 1.5% MWCNT



#### (b)PP with 3% MWCNT

#### Fig 4. SEM micrograph of the blending of PP/MWCNT

#### **IV. CONCLUSION**

Fourier transform infrared spectroscopy studies, tensile properties, and Morphological studies of PP/MWCNT blends were analyzed. The material is ideal for automotive applications, including shock absorbers. The hydrophilic and amphiphilic materials collaborate to relieve the material's rigidity. For novel MWCNT-enhanced composite materials, the incorporation of MWCNTs into polymers represents a great scope and room to enhance mechanical properties, electrical conductivities, and thermal properties that lead to lighter weight, higher strength, conductivity promotion, enhancing system performances, together with wear resistance during its operation. MWCNTs can be combined with polymers, offering an efficient, cost-effective solution that is both low maintenance and simple to produce, making it suitable for various automotive applications.

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