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"A study on the Synthesis, representation, and implementation of different polymer composites"

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Abstract:

Polymer composites have gained significant attention in various industries due to their unique properties and wide range of applications. This study aims to explore the synthesis, representation, and implementation of different polymer composites, focusing on their composition, processing techniques, and performance characteristics. The synthesis of polymer composites involves the combination of a polymer matrix with reinforcing materials, such as fibers, nanoparticles, or fillers. The choice of reinforcing material and its dispersion within the polymer matrix significantly impact the properties of the resulting composite. Various synthesis methods, including melt blending, solution casting, and in-situ polymerization, are discussed, highlighting their advantages and limitations. The representation of polymer composites involves characterizing their structure and properties using advanced techniques, such as scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD), and thermal analysis. These characterization methods provide valuable insights into the morphology, dispersion, and interfacial interactions within the composite, aiding in understanding the structure-property relationships.

Keyword: - Polymer, Composites, Nanoparticles, Techniques, Valuable.

Introduction

Polymers vary from molecules with a low molecular weight, such as alcohols, in that they are more complicated and larger in size. Ethanol has a molecular weight of 46, but a polymer might have a molecular weight of hundreds of thousands. Macromolecules are another term for these molecules. A polymer is a big molecule made up of several smaller molecules that have been repeatedly combined. The polymer is the result of the interconnection of numerous units, and hence, poly means 'many' and mer means 'part' (in

Greek). The repeat might be linear in certain circumstances. Sometimes the chains are joined in a three-dimensional network by branches or links. The polymer's repeating unit is generally the same as, or nearly the same as, the monomer from which it was made.

A broad range of sectors, including automotive, rail, aerospace, and marine, are now considering composites as a viable alternative to conventional materials. Chemical or physical combination of two or more distinct materials yields a composite material with a desired set of qualities, which may be further refined to meet the demands of varied applications.

Such a mix of qualities does not exist in typical materials such as metals, ceramics and alloys. When two or more separate materials are combined to produce a composite material, it has enhanced bulk characteristics that are unique from those of any of the individual components.

Generally, composites contain two phases:

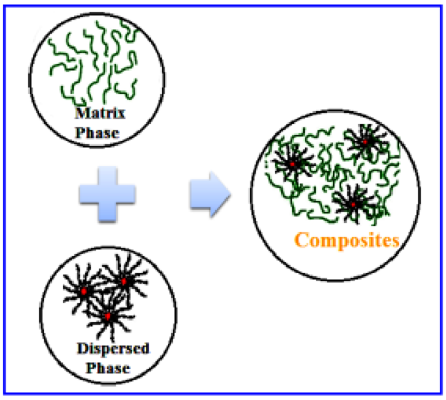

Figure 1: Two phases of composites

Nature has provided the inspiration for the manufacturing of composite materials. These natural composite materials include plant and animal bones, as well as tree trunks and stems. Physical and mechanical characteristics of the components in a composite material are determined by the strength of their bonds. Composite materials have unique qualities that aren't present in their individual components. Components of composite materials are selected to have qualities that contrast significantly yet complement one another in order to get the best performance possible.

Composite materials may be made of metal or alloys, polymers (polymer composites), carbon and ceramic materials, as well as other materials (non-metallic composites). Composite materials are held together and shaped by their matrix or foundation. Multi-matrix or multilayer composites are composite materials that have a mixed matrix.

A wide range of industrial and home applications rely on plastics for their easy processing and wide range of characteristics. It is possible to alter the repetitive structure of polymers to fulfill particular requirements. This may be done by varying the molecular distribution and mass of the molecules.

Review of Literature

Golmakani, M.E. et al., (2021) In this study, injection-molded composites of wood flour-reinforced polyethylene polymer and a coupling agent were created. The mechanical characteristics of the composites were studied in relation to factors such as wood flour size, aspect ratios, and mould injection temperature. Five distinct formulas were developed for use in making the polymer composites. Its tensile and modulus strengths, flexural and impact energies, and modulus of elasticity were all evaluated. Mechanical static and impact testing was carried out in order to look into the variations in characteristics caused by the various mixtures. The obtained findings show that the tensile strength and modulus, flexural strength, and impact energy were decreased upon decreasing the flour size. Instead, there was an improvement in the flexural modulus. In addition, the tensile strength, modulus, and impact energy of the specimens all decreased when injection molding temperature was raised. Contrarily, both the flexural strength and modulus rose. As a result, the mechanical characteristics of the composite may be enhanced by optimizing the injection molding temperature.

Haw-Ming Huang (2020) Composites are man-made materials composed of at least two different building blocks. It is possible to create materials with exceptional mechanical characteristics and organic activity by joining polymers with other materials, which can increase attributes of individual polymers such as mechanical strength, surface quality, and biocompatibility. In addition to their traditional uses in aerospace, automobile, military, and sports, polymer-based composites are finding increasing application in biomedicine, where they are being put to work in tissue engineering, wound dressings, drug discharge, regenerative medication, dental pitch composites, and surgical procedures [1, 2, 3]. Issues of post-integration material qualities and the optimum means of coordinating these materials are central to the topics that guide exploration in this area.

GökdenizNeşer (2017) Engineers in the marine industry and those working on the development of boats might reap some benefits from making use of polymer-based, fiber-reinforced composites (FRP). This article provides a brief overview of the development of FRP boats, mostly in the United States and Europe. Potential exploration subjects are also briefly highlighted, and maritime engineers are given a glimpse into the future of FRP applications in the marine sector in terms of materials, manufacturing procedures, and ecological concerns.

Omrani et al. (2016) looked into the tribological behavior of polymer matrix composites reinforced with natural fibres. Industries including the automotive, packaging, and construction sectors have shown significant interest in natural fibre reinforced composite materials. Special references on natural fibre reinforced composites were offered, including topics such as the kind of fibres, treatment of fibres, matrix polymers, and test parameters. As a consequence, treated and normally oriented fibres exhibited enhanced tribological characteristics, including reduced friction and wear. The natural composite has great tribological qualities and also has beneficial economic and environmental effects; therefore it has a lot of promise in many different uses.

Problem Statement

Natural fibers can be delivered in numerous sorts of reinforcement composites, like persistent and intermittent unidirectional fibers, arbitrary direction of fibers, and so forth By taking the benefits from those sorts of reinforced composites, for example, delivered good properties and diminished the fabrication cost, they had been utilized in the improvement of automotive, packaging and building materials.

There certain polymers which are degradable and eco-friendly yet those are not good enough for engineering applications. By supporting these sorts of polymers, we can accomplish more valuable material which can use in industrial.

Objectives of the Study

1. To investigation the scientific and commercia view on the Sal wood flour polymer and Neem wood flour composites
2. To survey PP/SEBS/Sal wood flour and PP/SEBS/Neem wood flour framework with adjusted stiffness and sturdiness properties
3. To analyze the Mechanical properties including Tensile strength, Modulus strength, Impact strength, after before Salt Spray
4. To investigation the impact of coupling specialist PP/SEBS/wood flour.
5. To carried out the Comparison of the properties in PP/SEBS and PP/SEBS/Salwood flour and PP/SEBS/neem wood flour for all volume portion of the wood utilized
6. To develop wood plastic (WPCs) composites, particularly for marine, exterior decking, exterior board, building material and liable to be utilized for more extensive array of applications in future

Research Methodology

Materials Used

This chapter explains the specifics of composite manufacturing as well as the experimental methods used to characterize the materials' mechanical properties.

- Polypropylene (PP) - Purchased from Reliance Polymers in Vadodara, India, is Polypropylene (PP), H110MA, with MFI 11g/10min (230oC, 4.16 kg).
- SEBES (styrene-ethylene-butylene-styrene) - Shell Chemical Co. in the USA sells the elastomer SEBS Kraton FG 1901 MFI 4.6g/10min (190oC, 4.16 kg).
- Sal wood flour - Locally sourced sal wood floor is further sieved before use. Using a density gravity bottle with a mesh size less than 180 m (BSS-85), the density of wood particles was determined to be 1.0018 gcm-3. Prior to manufacture, the wood dust is dried for 24 hours at 80^{o}C in a vacuum oven.
- Neem Wood Flour - Before used, neem wood flour is further sieved after being purchased locally. The density of the wood particles was determined to be 1.0017gcm-3 using a density gravity bottle with a mesh size of less than 180 m (BSS-85). The wood dust is dried in a vacuum oven for 24 hours at 80°C before production.

Procedures Applied

- **Bending of Melt**

Pre-drying was done at 80oC for 5 to 8 hours on the elastomer SEBS and 5 to 8 hours on the sal wood flour. On a co-rotating, twin-screw compounder, Model PTC/TH/40 (L/D=40, dimension D=21 mm), at a screw rotation speed of 600 rpm, blends of PP/SEBS with varying percentages of SEBS from 4.5 to 20 w/w (%) were created. The range of temperatures from the feed zone to the dying zone was kept between 190 C and 230 C. On the same twin screw compounder, composites of PP/SEBS/Sal Wood Flour (SWF) and Neem Wood Flour (NWF) were also created with varying wood content concentrations ranging from 10 to 50 w/w (%). From the feed zone to the die zone, the temperature was maintained at 160 C to 190 C, and the screw rpm was 198. The extruded strands were pelletized after being passed through a water bath that was at room temperature.

Sample Preparation

Twin screw extruders were used to dry the pellets of blends and composites for 5 hours and 8 hours, respectively, before they were injection moulded on a Model SP 50 TC-tonnage-50 machine. From the feed zone to the die zone, the barrel's temperature ranged from 100 C to 175 C, and the mould temperature was maintained at 2302 C.

Testing of Mechanical Properties

- **Test For Tensile**

Dumbbell samples that were 16.5 cm in length, 1.3 cm in width, and 0.32 cm in thickness were put through tensile testing on an Instrom Model 3369 (United Kingdom) at crosshead spacing of 50 mm at a speed of 50 mm/min in accordance with ASTM D 638 method.

- **Impact test**

According to the ASTM D256 standard, the impact strength of notched specimens was measured using a Chest, Model ResilImpactor (Italy) (length 6.35 cm and width 1.27 and thickness 0.32 cm). The average of five tests performed on each composition is presented. All experiments lasted 40 hours with temperatures kept at 23 2°C and relative humidifies kept at 50 10% RH.

- **Salt Spray test**

The Salt Spray tests were done on Salt Spray chamber Weiss Umwelttechnik (Germany) according the ASTM B 117:03 method.

The samples were evaluated for 72 hours with 5 wt (%) sodium chloride. Again, tensile and impact tests were conducted after the samples had air dried for 24 hours at room temperature (after an initial soak of 72 hours).

Results

Composites' Mechanical Properties

Mechanical properties of composites are significantly influenced by the PP and SEBS, as shown by their characterization. Table 4.1 lists the investigated composite types along with their corresponding properties.

The SEBS (from 2.5% by weight to 20% by weight) content of the specimens was prepared in a wide range of permutations. These samples were tested for their tensile and abrasive strengths. The results of research into salt spray's effects are shown in table 4.1.

Table 1: The composition percentage of PP -SEBS with different wt%

Sl. No.	Composition (wt%)	Tensile strength (MPa) Before Salt spray	Tensile strength (MPa) After Salt spray	Tensile Modulus (MPa) Before Salt spray	Tensile Modulus (MPa) After Salt spray	Impact Strength (kJ/m^2) Before Salt spray	Impact Strength (kJ/m^2) After Salt spray	Elongation at Break (%) Before Salt spray	Elongation at Break (%) After Salt spray
1	Pure PP	35.53	35.90	1744	1743	2.44	2.29	16.93	16.55
2	2.5	33.88	34.22	1690	1672	3.69	3.35	209.81	22.47
3	5.0	32.82	32.90	1663	1731	4.36	4.00	25.41	226.41
4	10	29.85	29.97	1450	1557	5.44	4.83	246.10	219.71
5	20	25.34	25.07	1194	1200	10.40	11.77	592.43	522.55

Mechanical Characteristics of Composites

The composites' mechanical characterization shows that the polypropylene, Sal wood flour, and SEBS are all having a noticeable impact. In Table 4.2, we analyze and compare the properties of various composites.

The SEBS concentrations used to create the specimens ranged from 2.5% to 20%. Table 4.2 displays the results of a comparison of the material's impact strength, tensile strength, and tensile modulus measured before and after exposure to salt spray.

Table 2: SEBS (10 wt%) and Polypropylene with different wt% of Sal wood flour

Sr. no.	Wood flour (%) With fixed SEBS-10 wt%	Tensile Strength before salt spray (MPa)	Tensile Strength after salt spray (MPa)	Tensile Modulus after salt spray (MPa)	Tensile Modulus after salt spray (MPa)	Impact Strength before salt spray (kJ/m²)	Impact Strength after salt spray (kJ/m²)	Elongation at Break before salt spray (%)	Elongatio n at Break before salt spray (%)
1.	Pure PP	35.53	35.90	1774	1734	2.44	2.29	16.93	16.55
3.	10	29.44	28.69	1693	1684	4.54	4.20	26.99	31.37
4.	15	30.41	29.15	2043	1864	3.53	4.16	17.89	26.43
5.	30	30.47	28.62	2079	1996	4.16	4.10	14.26	24.23
6.	50	30.15	28.48	2242	2063	4.21	4.77	3.57	10.16

Composite's Mechanical Characteristics

The composites show of characterization i.e SEBS, PP and Neem wood flour having significant effect on mechanical properties of composites. The mechanical properties of the wood plastic composites under investigation are presented in table (6.2). The different specimen were prepared with combination of fixed SEBS (10wt%), with varied Neem wood flour (0-50 wt%) contents. Impact strength, tensile Strength, modulus properties were studies on these specimens. The effect of maleic anhydride can be studied on the properties profile of SEBS/Polypropylene/Wood flour composites. In below table effect of Salt Spray were also studies and presented in Table 4.3.

Table 3: SEBS(10 wt%) and Polypropylene with Different wt% of Neem wood flour

Sr. No.	Wood flour(%) With SEBS(10 wt %) fixed	Tensile Strength(MPa) BeforeSaltspray	Tensile Strength(MPa) AfterSalt spray	Tensile Modulus(MPa) BeforeSalt spray	Tensile Modulus(MPa) AfterSalt spray	ImpactStrength(kJ/m²) BeforeSalt spray	ImpactStrength(kJ/m²) AfterSalt spray	Elongationat break Before saltspray %	Elongationat break Aftersaltspray %
	Pure PP	35.53	35.90	1774	1734	2.44	2.29	16.93	16.55
	10	28.38	28.33	1121.23	1142.43	4.04	3.82	14.04	14.06
	15	28.87	29.41	1261.31	1182.20	3.95	4.12	16.50	16.14
	30	29.47	29.00	1489.9	1398.55	3.84	3.48	6.20	5.93
	50	27.42	26.84	1783.82	1753.65	3.85	3.97	5.21	4.68

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