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Review Article

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Study of Different Types of Reinforcements in Polymer Composites - A Review

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Abstract

In the recent world of technologies enhancement in the properties of the materials composite material plays a vital role in our industrial growth with improved features. In this literature a detailed study was done on the reinforcements and their effect on physical and mechanical properties of polymer composites that are broadly used in various automobile, aerospace, and marine industries. The different polymer base, reinforcements such as graphene, carbon nanotubes, natural fibers, petrochemicals, vegetable oils, glass fibers and their effects have been studied. It was found that with addition of different natural, carbonous, petrochemical, vegetable oil-based reinforcements in polymer base composite, the instance thermal, mechanical, and physical properties were enhanced.

Keywords

Polymer composite, Carbon nanotubes, Graphene, Green polymer composites

Introduction

Present studies show researchers developed next level composite material centred on such as elastomer polymers, thermosetting polymers, and thermoplastic polymers. Such as organic or inorganic fibers, natural fiber, graphene, glass fiber are reinforced in the next level composite material invented using different fillers like organic, natural mineral, and metallic. Additional, studies represent growth and the creation of several macromolecular matrices specifically such as polyether imide, epoxy resin, polyether sulfone, polyether ether ketone, phenoplasts, polyhexamethylene sebacic, and polyethylene terephthalate. Composite material invented using different fillers have brilliant superior thermal resistance, mechanical properties, abrasion resistance, good fire behaviour, great impact resistance, super rigidity, and extraordinary electric insulation [1].

The Idea of invention is actual wide since it interests totally industries which grow intermediates or final goods by addition some raw materials [2, 3]. Exactly, the invention explained that all the information and functions applied while adding, conjoining, or modelling components of natural and artificial basis, repeatedly unsuited with one-another, hence it finds a marketable manufactured goods categorized by purpose of utilization and ability to meet a predetermined standard [4-6]. Including the factors of formula, a difference need be prepared between the active components which satisfy the most important function required and invention benefits the performance auxiliary functions [7, 8]. Researchers' efforts have resulted in the formation of polymer composites [9]. In comparison to the traditional steels and alloys preferred in almost of structural applications, polymer matrix composites are more lightweight, affordable, and anti-resistive and have greater specific strengths. As a consequence, the usage of polymer composites in structural components might aid in the elimination of

serious issues like rusting, wear and tear, which result in a loss of substances and subsequently resources. Additionally, due to their small weight, polymer composite structural components will require less money for shipment [10, 11]. Due to its lightweight qualities, using polymer composites would not only save money and materials but also decrease energy usage and carbon impact [12]. These are the primary factors attracting the scientific community's attention to polymer composites. The main problem facing the materials research community right now is a decrease in weight and greenhouse gas emissions to avoid pollution. This prompted several companies to adopt polymer-based components [13, 14]. In the aircraft industry, polymer matrix composites are utilized in such as wing sections, finishing, and fins. Similarly, it is also used in military battleships, weapons aircraft, and fireproof clothing [15]. Polymer matrix hybrid components are used by the electrical and electronic sectors in products including smart notebooks, desktops, cello-phones, refrigerators, air compressors, smartwatches, etc. Researcher's research on various polymer to develop hybrid polymer composites using different types of reinforcement such as natural fiber-based, bio-based, and petrochemical-based, nanoparticle-based, glass fibers, and graphene based-polymer composite. The effects of reinforcement on the unique properties of various polymer composites have been comprised in table 1.

Natural Fiber-based Polymer Composite

Zini and Scandola [19] shows flax, banana, kenaf, jute, hemp, sisal, oil palm, and fruit bundles are a few examples of natural cellulose fibers. The major manufacturers of natural fibers in Southeast Asia, Indonesia, and Malaysia have trouble or problems handling the cellulose fibers of empty fruit bundles, so it makes sense to renovate the waste into beneficial reinforcement. The plastic reinforcement's natural fibers have advantages as are low density, renewable, biodegradable, non-toxic, good insulating properties, and equipment wear. In the automobile sector, natural fibers' low density is very advantageous. Natural fibers harmfully affect the mechanical properties such as fracture toughness, flexural modulus it due to limitations of nature fibers like high moisture absorption, poor wettability, and incapability.

Bio-based Polymer Composites

Based on fossil fuels renewable resources are getting rapid depletion, so alternative requirement is widely increased, researcher motive to growth of ecological, eco-friendly, and decomposable materials utilized of its high-end uses. Pokharel et al. [20] found that ease of the ecological effects caused by no biodegradable materials, the researching of bio-composites with developed mechanical properties. Natural fibers like Jute twine, flax seed, and hemp were effectively mixed with bio composite improvement. However, it cannot be misjudged the effects of functional moieties during their life cycle. Applications for bio-composites may be found in many fields, including biomedical, packaging, and the aerospace engineering sector. To develop bio-composites' applications, they must have better strength, efficiency, long service life, and dependability.

Petrochemical-based Polymer Composites

Singh et al. [21] represents that reliance on polymers made from petroleum have greatly risen. Petroleum hydrocarbons give rise to synthetic materials polymer including polyethylene, polypropylene, nylon, polyester, epoxy, and polytetrafluoroethylene. Mariano et al. [16] researched on polymers that are extremely multipurpose group of compounds—so resourceful, trendy detail, founded in all categories of unpredicted places. Humanity consumes synthetic polymers as several of them had extremely necessary qualities, such as durability, adaptability, resistance, low toxicity, and so on.

Nanoparticle-based Polymer Composites

According to Gill et al. [22], polymers and nanoparticles

Table 1: Various reinforcements and their effect on properties of polymer composites.

S. No.	Matrix Composites	Reinforcements	Findings	Reference
1	Polymer composite	Quartz powder and glass fiber	Wear resistance in quartz powder increased, attaining the greatest specified wear level.	[1]
2	Polymer composite	Tetrafunctional epoxy prepolymer mild steel	The increase in Anticorrosive protection efficiency was observed.	[3]
3	Thermoplastic Polymer Composites	Nanocomposites TiO_2/ABS	Explanation of various processing methods and thermoplastic composite materials used in 3D printing is presented.	[5]
4	Polymer	Natural fabric	Enhancing the fibers' compatibility with the material matrix and their hydrophilic potential.	[8]
5	Poly (lactic acid) Nanocomposites	Cellulose Nanocrystal	To enhance the dispersion of CNCs in a hydrophobic matrix, produce compatibilizing agents made of a diblock copolymer and an ionic liquid-PLA polymer.	[16]
6	Cellulose nanocrystals	Polystyrene	Despite anticipated better interfacial interactions, this phenomenon most likely explains the composites' rather mediocre mechanical characteristics.	[17]
7	Polymer composite	Graphene	The upgraded properties such as tensile strength, elastic modulus, electrical and thermal conductivity was observed.	[18]

are mixing with get innovations to introducing new engineering flexible composites that shows new advantages of optical, electrical, or mechanical properties. Polymer and nanoparticle combining has made it possible to create strong and flexible composites with beneficial electrical, optical, or mechanical characteristics. Current developments expose ways to activity of both enthalpy and entropic connections in order to handle the material's macroscopic effectiveness while also limiting the nanoparticles' 3D dispersion. For instance, by modifying the particle coating and size, researchers have created self-healing materials for efficient infrastructure and self-corralling rods for solar applications. Developing hierarchically organised composites in the future where each sublayer provides a dissimilar function to produce a mechanically integrated, multifunctional material is tough.

Glass Fiber-based Polymer Composites

Various manufacturing technology used to make glass fibers reinforced polymer composites and it had vast field applications. According to Venkatesa et al. [23], polymer with glass fiber reinforcement composites are produced using a variety of production techniques and are often employed in a wide range of applications. First, glass fibers brought in from heated, softened glass were used to create vessels by the ancient Egyptians. In the 1930s first glass fibers were prepared for high-temperature electrical application. There are several applications for electronics, aircraft, and automobiles. Brilliant properties glass fibers contain such as stiffness, flexibility, high strength and protection against chemical damage, studies reported some polymer with glass fiber reinforced composites have mechanical, vibrational, thermal, tribological water absorption properties.

Graphene-based Polymer Composites

According to Du and Cheng [18], graphene/polymer composites greatly outperformed conventional polymer composites in terms of tensile strength, elastic modulus, electrical conductivity, and thermal conductivity. Sun and Shi [24], reported that the surface properties of graphene and better control of interfacial properties in composites was found to be improved due to surface characterization techniques and graphene surface treatments.

Conclusion

Literature shows study about like natural fibers, organic and inorganic fibers reinforced to thermoplastic polymers, elastomer polymers and thermosetting and invention by fillers that recommended shows the following points:

- Natural fibers reinforcement material has wide range of use as these materials exhibit good properties (specific strength and stiffness) and natural fiber have low cost and abundant in nature they are good alternative over other.
- To ease of the environmental effects caused by no biodegradable materials, with developed mechanical properties of bio-composites were made.
- At high temperature, composite materials thermosetting exposed excellent mechanical and thermal resistance.
- Exceptional high tensile and compressive strength is showed by reinforced glass fibers and carbon to technological composite materials.
- Graphene-polymer composites are capable multifunctional materials with considerably upgraded properties such as tensile strength, elastic modulus, electrical and thermal conductivity, have wide potential applications and the availability of graphene in a large quantity at low cost.

It show that different filler have different effect on properties (superior thermal resistance, mechanical properties, abrasion resistance, good fire behaviour, great impact resistance, super rigidity, extraordinary electric insulation, tensile strength and elastic modulus, electrical and thermal conductivity, stiffness, flexibility, high strength and resistance to chemical harm mechanical, vibrational, thermal, tribological water absorption properties resistivity, chemical inertness) which improve the ability of material these are used in many modern field such as electronics, aviation, automobile, marine, aerospace, infrastructure, medical devices, sports safety product, and consumer goods.

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Conflict of Interest

The authors declare no conflict of interests that are relevant to the content of this article.

Credit Author Statement

Manish Kumar: Literature review, Writing - original draft preparation; Sandeep Kumar Khatkar: Writing - review and editing; Pawan Kumar: Schematic representation, Tabulation, Writing - review and editing; Amit Gupta: Writing - review and editing. All the authors read and approved the manuscript.

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