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EFFECT OF NANO FILLERS ON THE PROPERTIES OF HYBRID FIBER COMPOSITES – A GENTLE REVIEW

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Abstract:

In modern World there is huge Impact on development of different products. This paper is a brief review on the impact of nano fillers on the performance of composites, with a focus on hybrid fiber composites. The use of nano fillers has gained attention in recent years due to their ability to improve the mechanical, thermal, and electrical properties of composites. The authors discuss the types of nano fillers commonly used in composites, such as carbon nanotubes, graphene, and nano clay, and the various methods of incorporating them into composite materials. They also explore the effects of nano fillers on the mechanical properties, such as tensile strength, flexural strength, and impact strength, as well as the thermal and electrical conductivity of composites. The review highlights the potential of using nano fillers to enhance the performance of hybrid fiber composites, making them suitable for a wide range of applications in various industries.

1.Introduction

Composite materials have gained significant attention in recent years due to their unique combination of properties, such as high strength, stiffness, and toughness. One way to further enhance the properties of composites is by incorporating nano fillers, which are materials with at least one dimension less than 100 nanometers. Nano fillers have been found to significantly improve the mechanical, thermal, and electrical properties of composites, making them suitable for a wide range of applications in various industries. Hybrid fiber composites are a combination of different fibers, such as carbon, glass, and aramid fibers, and offer a unique combination of properties. The addition of nano fillers to hybrid fiber composites can further improve these properties, making them even more versatile and applicable.

Olayil, R(2021) discusses the types of nano fillers commonly used in composites, such as carbon nanotubes, graphene, and nanoclay, and the various methods of incorporating them into composite materials. The authors explore the effects of nano fillers on the mechanical properties, such as tensile strength, flexural strength, and impact strength, as well as the thermal and electrical conductivity of

composites. The review emphasizes the potential of using nano fillers to enhance the performance of hybrid fiber composites, making them suitable for a wide range of applications in various industries, including aerospace, automotive, and sports equipment.

Nano fillers have emerged as a promising approach for enhancing the mechanical properties of natural fiber polymer hybrid composites. The addition of these small-sized materials has been shown to improve the tensile, flexural, and impact strength of composites. With their high surface area to volume ratio and unique physical and chemical properties, nano fillers can significantly improve the interfacial bonding between natural fibers and polymer matrix, leading to improved mechanical performance. Various types of nano fillers, including carbon nanotubes, graphene, and nanoclay, have been used in natural fiber polymer hybrid composites. This review paper provides an overview of the effect of fillers of various sizes on the mechanical properties of natural fiber polymer hybrid composites. Singh, H(2019) discuss the various methods used for incorporating nano fillers into composites and highlight the challenges associated with their processing and characterization.

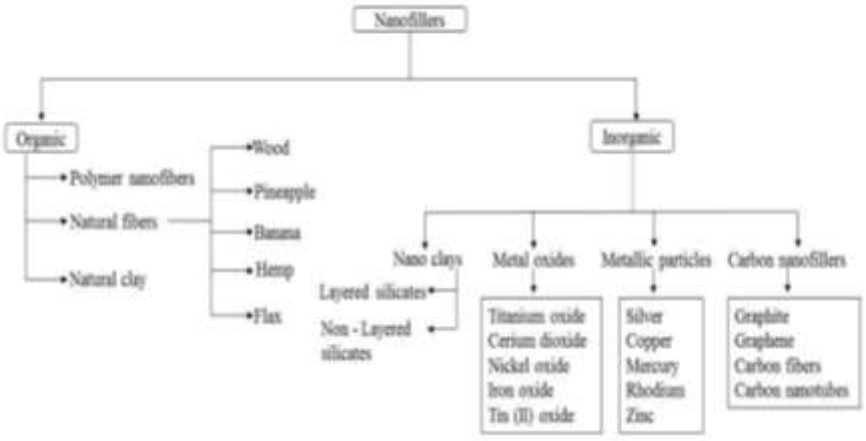

Fig 1. Classification of Nano filler materials

Jagadeesh P (2023) identifies that Natural fiber composites Mechanical properties are increased by different nano fillers like aluminum oxide, titanium oxide such as titanium dioxide, aluminum oxide, Calcium carbonate, silicon carbide, zinc oxide in various ratios. Natural filler materials have gained significant attention as an eco-friendly and sustainable alternative to synthetic fillers for enhancing the properties of fiber reinforced hybrid polymer composites.

2. Hybrid fiber Composites

Hybrid fiber composites, which combine the benefits of two or more types of fibers, have gained significant attention in recent years. The addition of natural filler materials to these composites can

further enhance their properties, making them attractive for a wide range of applications. Hybrid fiber composites have shown improved mechanical properties such as tensile, flexural, and impact strength, as well as thermal and electrical conductivity, compared to single-fiber composites. The use of natural filler materials in these composites can also improve their sustainability and environmental impact. Jagadeesh P (2023) provides a comprehensive understanding of the effect of natural filler materials on the properties of fiber reinforced hybrid polymer composites, which can guide the development of more sustainable and high-performance composite materials.

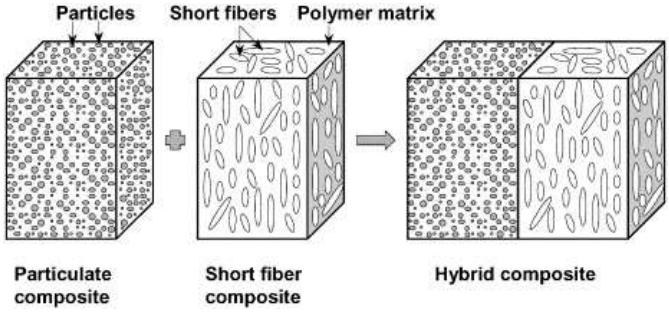

Fig 2. Hybrid composites

3. Study of Nano filler materials

Nano fillers are materials that have a particle size in the nanometer range, typically between 1 and 100 nanometers. These fillers are more entensively used in the development of hybrid composites because of their exceptional properties like high specific surface area, improved mechanical properties, and superior thermal and electrical conductivity.

Hybrid composites are materials that combine two or more different types of reinforcing fibers, with a matrix material, such as epoxy, polyester, or nylon. By adding nano fillers to the matrix material improves their properties, resulting in a material with enhanced strength, stiffness, and toughness. There are various types of nano fillers that can be used in hybrid composites, including:

Carbon nanotubes (CNTs): carbon nanotubes are cylindrical in shape with a diameter in the range of nanometers. CNTs possess excellent mechanical properties, making them ideal for use in hybrid composites.

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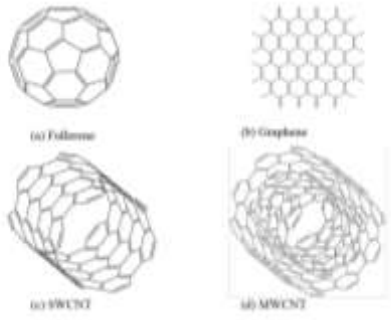

Fig 3. Carbon Nano-fillers

Graphene: Graphene is a single layer of atoms(carbon) arranged in a lattice. It is a Two- dimensional material. Graphene has high strength, excellent thermal and electrical conductivity, making it an option for hybrid composites.

Nano clay: These are platelet-shaped particles made of layered silicates. Nano clay has high aspect ratios and excellent barrier properties, making them ideal for use in polymer composites.

Nanofibers: These are fibers with diameters in the nanometer range. They can be made from various materials, including carbon, ceramic, and polymers. Nanofibers are ideal for use in composites because of their high surface area and good mechanical properties.

Overall, By adding nano fillers to hybrid composites improves the mechanical, electrical and thermal properties.

4. Methodologies

There are various methodologies used to fabricate nano fillers mixed hybrid composites, some of which are outlined below:

Solution mixing: In this method, the nano fillers are mixed with the polymer matrix material in a solvent, followed by evaporation of the solvent to form a composite. This method is simple and easy to implement, but the distribution of the nano fillers may not be uniform throughout the composite.

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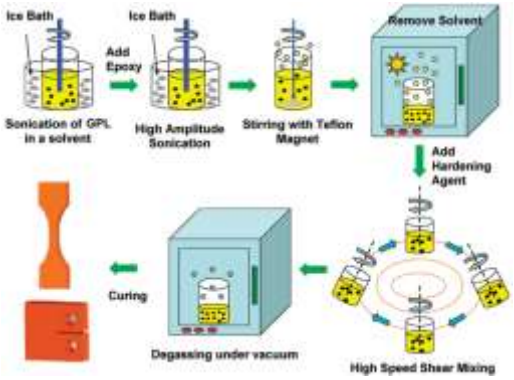

Fig 4. Solution mixing method

Melt mixing: In this method, the nano fillers are mixed with the polymer matrix material in a molten state using mechanical mixing techniques such as twin-screw extrusion or injection molding. This method can produce composites with uniform distribution of the nano fillers, but the high processing temperatures may result in degradation of the polymer matrix material.

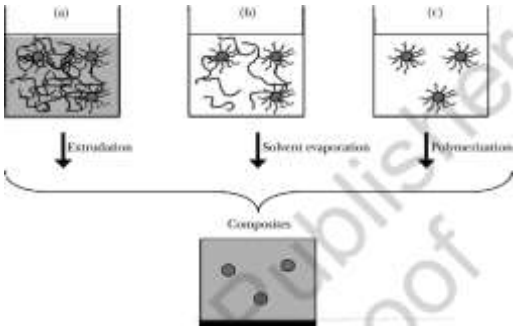

Fig 5. Melt mixing

In-situ polymerization: In this method, the nano fillers are added to the monomer or pre-polymer, followed by polymerization to form the composite. This method can produce composites with excellent bonding between the nano fillers and matrix material, resulting in improved mechanical properties.

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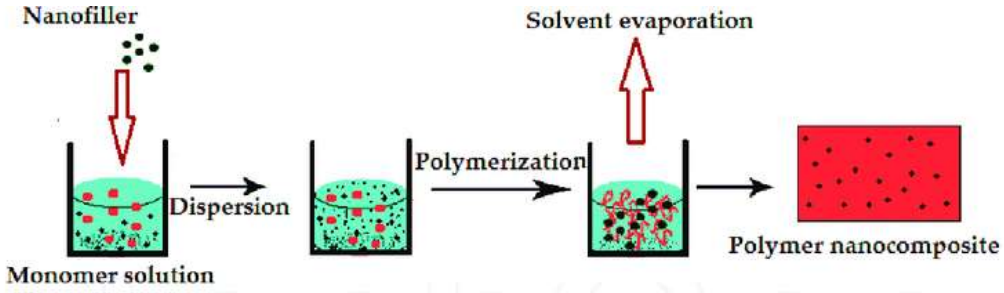

Fig 6. In-situ polymerization

Layer-by-layer assembly: In this method, the nano fillers and polymer matrix material are alternately deposited onto a substrate to form a multilayer composite. This method can produce composites with precise control over the layer thickness and compositionss. Each method has its advantages and limitations.

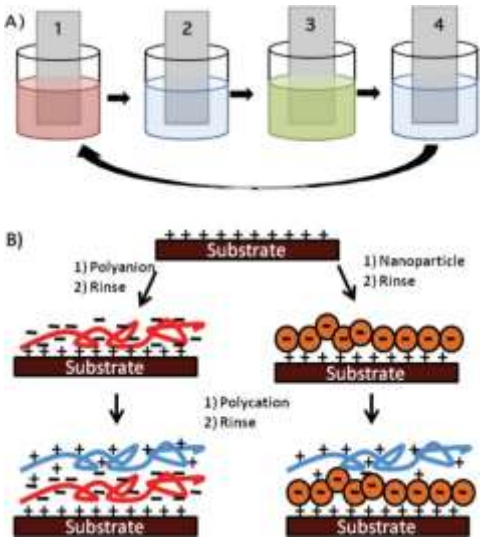

Fig 7. Layer by layer Assemnbly

Electrospinning: In this method, a polymer solution containing the nano fillers is electrospun to form nanofibers, which are then collected to form the composite. This method can produce composites with high surface area and improved mechanical properties.

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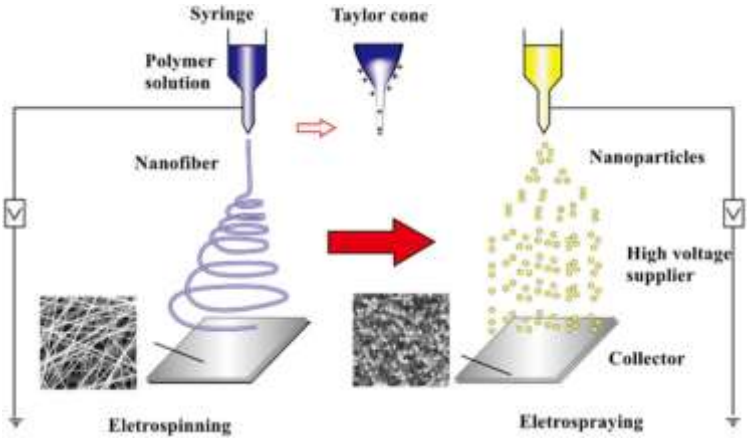

Fig 8. Electro-spinning

5. Effects of filler materials on properties of Hybrid fiber composites

The addition of filler materials to hybrid fiber composites can significantly affect their properties, including mechanical, thermal and electrical. Below are effects of filler materials on the hybrid fiber composites properties are outlined below:

Mechanical properties: By adding the nano fillers can enhance the mechanical properties of These fillers can increase the stiffness, strength, and toughness by increasing the strong bonding between the Reinforcement and matrix material, increasing the load transfer efficiency, and inhibiting crack propagation.

Thermal properties: The addition of fillers such as boron nitride and aluminum oxide can increase thermal conductivity and stability of hybrid composites. heat transfer efficiency of the composites can be increased by nano fillers and prevent thermal degradation of the matrix material.

Electrical properties: By adding the nano fillers can enhance the mechanical properties of can significantly improve the electrical conductivity of hybrid fiber composites. These fillers can enhance the charge transport efficiency of the composites and make them suitable for different applications.

Barrier properties: By adding the nano fillers can enhance the barrier properties of hybrid fiber by reducing the permeability of gases and liquids. These fillers can create tortuous paths for the diffusion of molecules and prevent the ingress of moisture, oxygen, and other corrosive agents into the composites.

Overall, the choice of filler material depends on the different properties. The optimal amount and dispersion of the filler material within the matrix material are also critical factors that influence the properties of the composites.

Jagadeesh p (2023) explain Natural fillers are preferred over synthetic fillers by many researchers, scientists, and businesspeople today because of their favourable mechanical qualities, environmental friendliness, low cost, reduced tool wear, and low density per unit volume.

Sasidharan, S (2020) observes Due to their distinct physical features, carbon-based nanofillers are thought to be the most appealing among the numerous nanofillers utilised to change the epoxy matrix. In an epoxy matrix, fullerenes are shown to perform better than nanoparticles of nano silica, nano alumina, and nano titanium. This is likely because of their hollow structure, which leads to a decrease in weight and an increase in specific surface area. Nanoclay is a two-dimensional nanomaterial that naturally occurs as platelets and has anywhere between a few and 1000 sheets. Most of these are silicates, and they are reasonably priced. The research community has become interested in silica (SiO_2) nanoparticles or nano silica because of characteristics.

Due to their advantageous features, nanoparticles are far more frequently used as reinforcement in polymer matrix composites than micro fillers. Shubham (2020) observed The link between the fibre and matrix in The term "nano fillers" refers to composite materials. Epoxy resin and nanoparticles are properly dispersed using an ultrasonication method. Silica (SiO_2), aluminum oxide (Al_2O_3), titania (TiO_2), and graphite are a few often utilized nano particles.

With ward modification, the thermal stability of SiO_2 nanoparticles decreased, whereas wood preserved with SAN, SiO_2, and nano clay had increased thermal stability. Scanning electron microscopy was used to observe morphological traits (SEM). Through the incorporation of SiO_2 and nano clay, mechanical characteristics. By adding Sio2 and nano clay the wood powder polymer composites will give enhancement in properties [Sinha(2020),Aravindh(2022),Chavhan(2020)].

Strength is the main aspect for Industrial applications market's growth in composites reinforced with natural fibers. Fiber-reinforced composites have more uses now thanks to this wide range of advantages in the automotive applications. physical and mechanical properties improve when nanofillers are added. In this article, several investigations into the effects of various elements [Chavhan (2020)].

High price in comparison to metals, Joints between composite materials and metal are crucial, Manufacturing takes longer than it does with homogeneous materials, Repair following crack initiation is challenging [Hemath(2020), Ghanta(2020)].

Reuse and disposal could be challenging, Filler-particle-based composites are challenging to finish, compared to metal, composite laminates are more brittle, Inspection and testing are frequently more difficult [Nayak, S(2022)]. According to the aforementioned study, the mechanical characteristics of composite materials were improved as a result of the hybridization of various materials. These are some of the causes behind the improved mechanical properties in the laminated type of hybrid fibre composites [Atmakuri, A.(2020),Rajeshkumar, G (2022)].

The investigation examined the mechanical, electromagnetic radiation shielding, thermal conductivity, and viscoelastic properties of nano composites.[Sadangi, A(2022),Joseph, G(2021).Kumar, A(2021)]. The qualities that are mostly influenced by the degree of dispersion inside the polymer resin are impacted by the hybrid nanofillers. The results of the polymer nanocomposites are significantly decreased or adversely affected by the accumulation of any number of nanoparticles, whether it be one, two, or more. Due to the choice of hard material, formulation, and other processing variables, the composites' electromagnetic radiation shielding capabilities have significantly improved [Verma, R(2020),Vinayagamoorthy, R(2020),Shettar, M(2017)]. By considering the dispersion of nanoparticles and reducing the viscosity of the polymer, the review effectively proved the shielding effectiveness of Nano-FiRPC [Devaraju,,Patil, A(2021)]. By inset polymerization, can increase the over all properties like mechanical, chemical and thermal properties [Rasana(2018),Devnani(2019)].

By using the nano silica, nano calcium and other nano particles can increase impact strength. Mainly increased by using nano calcium carbonate [Badgayan,Joshua(2021)]. By adding nano particles like si02, cac03, CaSiO, Al2o and Tio2 powder to the matrix material improves all the properties [Devaraju(2019)]. Three types of nano fillers are used to used to increase the performance of the the composites. One-dimensional, two- dimensional and three-dimensional nanofillers.[Suresha(2018)].

6. Conclusion

In conclusion, To sum up, the incorporation of nano fillers into hybrid fiber composites has been found to significantly enhance their properties. The reviewed literature highlights the effectiveness of various types of nano fillers in improving mechanical, thermal, and electrical properties of the composites. Moreover, the synergistic effects of combining different types of nano fillers have been demonstrated

to further enhance the overall performance of composites. However, challenges related to the uniform dispersion and agglomeration of nano fillers in the matrix remain to be addressed. Overall, this brief review provides valuable insights into the potential of nano fillers in enhancing the properties of composites, paving the way for further research and development in this field.

- hat the addition of nano fillers in natural fiber polymer hybrid composites leads to significant improvements in mechanical properties. However, the size and concentration of fillers need to be carefully optimized to achieve desirable properties. Further research is needed to better understand the mechanisms underlying these improvements and to address challenges related to filler dispersion and agglomeration..
- the incorporation of nano fillers into polymer matrix composites has been found to significantly enhance their mechanical, thermal, and electrical properties. However, the dispersion of nano fillers and their interfacial bonding with the matrix are critical factors that need to be addressed to maximize the benefits of using nano fillers. Further research is needed to optimize the filler-matrix interaction and to explore the potential of these composites in various applications.
- Natural fiber composites can be enhanced with the addition of various fillers, such as Titanium Oxide (TiO2), Aluminum Oxide (Al2O3), Calcium Carbonate (CaCO3), Silicon carbide (SiC), Zinc Oxide (ZnO), and Zirconium Oxide (ZrO2) in different ratios, which can significantly improve their mechanical properties. However, the effectiveness of the fillers depends on various factors, such as their dispersion within the composite, the interfacial bonding between the filler and polymer matrix, and the distribution of the fillers throughout the composite. Proper optimization of these factors can result in composites with improved mechanical characteristics.
- the use of natural fillers in fiber-reinforced hybrid polymer composites has shown promising results in improving their mechanical, thermal, and barrier properties. The reviewed literature highlights the potential of various natural fillers and their optimized combinations in enhancing the properties of composites. However, further research is needed to address the challenges related to filler-matrix compatibility and to develop sustainable and cost-effective manufacturing processes for these composites.

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