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NANO TECHNOLOGY IN TEXTILE FIBRE REINFORCED COMPOSITES - A REVIEW

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ABSTRACT

The textile composites industry is experiencing a consistent and positive response from users. This industry is not only replacing traditional textile materials but also incorporating natural bast fibers and waste materials from related industries. Additionally, nanotechnology plays a significant role in enhancing the value of textile composites. Over the past decade, research on nanocomposites has garnered significant attention and media coverage due to the immense benefits it offers. Initially, these composites were developed as part of a robust manufacturing technology aimed at producing high-value, cost-effective materials under reasonable conditions. The applications of nanotechnology composites are diverse and include areas such as electronics, electromagnetic interference shielding, lightning strike protection, and medical textiles, among others.

***Keywords** – Composites; Nano composites; Nanotechnology; Hybrid materials.*

INTRODUCTION

In the realm of emerging materials, composite materials, plastics, and ceramics have taken the spotlight over the past three decades. The use and application of composite materials have steadily expanded, infiltrating and conquering new markets with unwavering determination. In today's engineering landscape, modern composite materials hold a substantial share, ranging from everyday products to specialized niche applications. While composites have already proven their worth as materials that reduce weight, the current challenge lies in making them economically viable. The efforts to produce economically attractive composite components have resulted in several innovative manufacturing techniques currently being used in the composites industry. Among these innovations, nanotechnology stands out as an emerging field through which new productions on large scale can be manufactured. One notable area of interest in recent years is the development of textiles with antimicrobial properties using nanoparticles, a subject that has captured the attention of both scientists and consumers [1-4].

Metal nanoparticles, characterized by their unique electronic configuration, extensive surface area, and abundant surface atoms, exhibit exceptional properties. For instance, they display a broad absorption band in the visible region of the electromagnetic spectrum. These remarkable properties of metal nanoparticles are harnessed to enhance the photocatalytic activities of semiconductors like $TiO2$ and $SiO2$, making them highly efficient, even under visible light. Certain noble metals, including Ag, Au, and Pd, have proven their worth in the production of nanocomposites. Nano silver, a standout nanomaterial among noble metals, finds applications in diverse industries such as medicine, biochemistry, electrochemistry, optics, and notably, the textile industry, where it imparts valuable antimicrobial properties [5-11].

It is well-established that nanoparticles possess distinctive chemical, electrical, optical, physical, and biological properties that can differ significantly from ion and bulk materials. These properties are primarily influenced by factors such as size, shape, composition, crystallinity, and structure. The synthesis method employed for metal nanoparticles plays a pivotal role in determining their size, shape, and morphology. Recognizing the drawbacks of conventional nanomaterial synthesis, which often involves hazardous chemicals, low material conversions, high energy demands, and wasteful purification processes, novel production methods are increasingly focused on "green synthesis." This approach incorporates non-toxic chemicals, environmentally friendly solvents, and renewable materials, aligning with sustainable practices. The antimicrobial activity of metal nanoparticles is believed to arise from their small particle size and high specific surface area, making them formidable agents in combating microbial threats [12-16].

TEXTILE COMPOSITES

“Composites are multifunctional material systems that provide characteristics not obtainable from any discrete material. They are cohesive structures made by physically combining two or more compatible materials, different in composition and characteristics and sometimes in form. For the sake of simplicity, however, composites can be grouped into categories based on the nature of the matrix each type possesses. Methods of fabrication also vary according to Physical and chemical properties of the matrices and reinforcing fibers.

POLYMER MATRIX COMPOSITES (PMCs)

The most common advanced composites are polymer matrix composites. These composites consist of a polymer thermoplastic or thermosetting reinforced by fiber (natural carbon or boron). These materials can be fashioned into a variety of shapes and sizes. They provide great strength and stiffness along with resistance to corrosion. The reason for these being most common is their low cost, high strength and simple manufacturing principles.

METAL MATRIX COMPOSITES (MMCs)

Metal matrix composites, as the name implies, have a metal matrix. Examples of matrices in such composites include aluminium, magnesium and titanium. The typical fiber includes carbon and silicon carbide. Metals are mainly reinforced to suit the needs of design. For example, the elastic stiffness and strength of metals can be increased, while large co-efficient of thermal expansion, and thermal and electrical conductivities of metals can be reduced by the addition of fibers such as silicon carbide.

Ceramic Matrix Composites (CMCs) Ceramic matrix composites have ceramic matrix such as alumina, calcium, aluminosilicate reinforced by silicon carbide. The advantages of CMC include high strength, hardness, high service temperature limits for ceramics, chemical inertness and low density. Naturally resistant to high temperature, ceramic materials have a tendency to become brittle and to fracture. Composites successfully made with ceramic matrices are reinforced with silicon carbide fibers. These composites offer the same high temperature tolerance of super alloys but without such a high density. The brittle nature of ceramics makes composite fabrication difficult. Usually most CMC production procedures involve starting materials in powder form. There are four classes of ceramics matrices: glass (easy to fabricate because of low softening temperatures, include borosilicate and alumina silicates), conventional ceramics (silicon carbide, silicon nitride, aluminum oxide and zirconium oxide are fully crystalline), cement and concreted carbon components.

CARBON-CARBON COMPOSITES (CCMs)

CCMs use carbon fibers in a carbon matrix. Carbon-carbon composites are used in very high temperature environments of up to 6000 of, and are twenty times stronger and thirty times lighter than graphite fibers.

NANO TECHNOLOGY

Nanotechnology involves the creation and manipulation of particles at the nanoscale, that is, particles that range in size from 1 to 1,000 nanometers (nm), where 1 nm equals 1 billionth of a meter. Nanomaterial includes single- wall carbon nanotubes (CNTs), which are long, thin cylinders of carbon atoms arranged in a graphitic lattice structure, and multiwall carbon nanotubes, which are concentric cylinders of carbon atoms in a similar graphite structure held together by weak intermolecular forces. These carbon-based particles have aspect ratios that range from 100:1 to 10,000:1.

MAKING OF COMPOSITES

Composites are hybrid materials made of a polymer resin reinforced by fibres, combining the high mechanical and physical performance of the fibres and the appearance, bonding and physical properties of polymers. Making of composites generally makes use of two materials which are as follow:

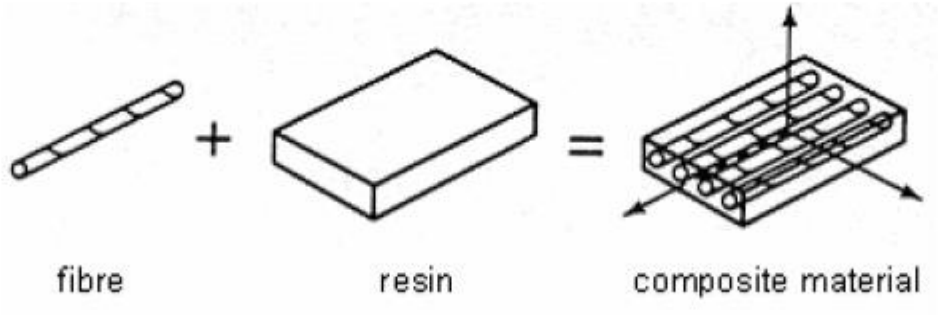

Fig. 1. Formation of composite

COMPOSITE COMPOSITION

The short and discontinuous fibre composites are responsible for the biggest share of successful applications, whether measured by number of parts or quantity of material used. The most important part in composites is that they are tailor made products i.e. their physical and mechanical properties can be molded according to the need of user. Therefore different layers of fibres are sandwiched together to obtain the composite material. As shown in the figure below we can observe that how fibres placed in different directions on combining together overcome the strength problems which they faced in individual stage.

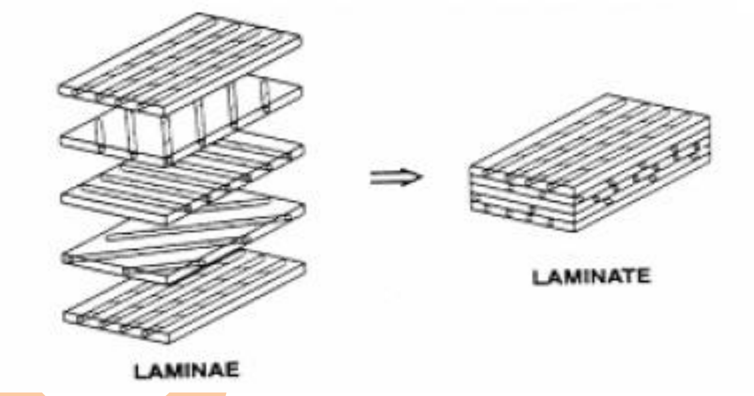

Fig. 2. Formation of composite composition

TAILORED COMPOSITES

The composite makes use of number of techniques for their manufacturing but the most commonly used manufacturing processes are as follow:

1. Hand laminating

2. Resin injection technique

3. Hot pressure method

4. Filament winding Pultrusion

CHARACTERISTICS OF THE COMPOSITES

A composite material consists of two phases. It consists of one or more discontinuous phases embedded in a continuous phase. The discontinuous phase is usually harder and stronger than the continuous phase and is called the ‘reinforcement’ or ‘reinforcing material’, whereas the continuous phase is termed as the ‘matrix’. The matrix is usually more ductile and less hard. It holds the dispersed phase and shares a load with it. Matrix is composed of any of the three basic material type i.e. polymers, metals or ceramics. The matrix forms the bulk form or the part or product. The secondary phase embedded in the matrix is a discontinuous phase. It is usually harder and stronger than the continuous phase. It servers to strengthen the composites and improves the overall mechanical properties of the matrix. Properties of composites are strongly dependent on the properties of their constituent materials, their distribution and the interaction among them. The composite properties may be the volume fraction sum of the properties of the constituents or the constituents may interact in a synergistic way resulting in improved or better properties. Apart from the nature of the constituent materials, the geometry of the reinforcement (shape, size and size distribution) influences the properties of the composite to a great extent. The concentration distribution and orientation of the reinforcement also affect the properties. The shape of the discontinuous phase (which may by spherical, cylindrical, or rectangular cross-sanctioned prisms or platelets), the size and size distribution (which controls the texture of the material) and volume fraction determine the interfacial area, which plays an important role in determining the extent of the interaction between the reinforcement and the matrix. Concentration, usually measured as volume or weight fraction, determines the contribution of a single constituent to the overall properties of the composites. It is not only the single most important parameter influencing the properties of the composites, but also an easily controllable manufacturing variable used to alter its properties.

APPLICATIONS OF NANO TECHNOLOGY IN TEXTILE COMPOSITES

1. Nano composite Plastics and Carbon Nanotubes in Packaging

2. Nano porous compounds in Insulation and Microelectronics

3. Nanoparticles in Plastic and Colloids

4. Nano Coatings

5. Smart Textiles

6. Nano encapsulation in composites for fragrance finishing

7. Nano compounds for making of Non-woven composites

CONCLUSION

The composite materials industry is currently experiencing a dynamic trend, with many products gaining significance through innovative amalgamations. It is evident that composites have demonstrated their value as materials that can reduce weight, but the prevailing challenge lies in rendering them economically efficient. This quest for cost-effectiveness has led to the development of inventive manufacturing techniques that are currently reshaping the landscape of the composites industry. Within this evolving context, nanotechnology stands out as a promising and emerging field that holds the potential to revolutionize large-scale production processes.

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