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A Comprehensive Review on Composites

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ABSTRACT

Composites are one of the most important materials of twenty first century having wide range of applications in the field of electronics to aeronautics and space industries. The excellent mechanical properties and low specific weights are basis of their demanding importance in technology. Polymer composites are a special type composite that are having organic or inorganic polymers as matrix and particles, small fibers in the range of millimeter to nanometer range are used as reinforcing material. These are tech friendly because of having remarkable features like light weight, high specific strength and high stiffness, economic efficiency, easier way of fabrication, good resistance towards fatigue, etc. In polymer nanocomposites solid particles or fibers in the nano range (<100 nm, in at least one dimension) are embedded in polymer matrices. They are very important for industrial applications due to their very high surface area compared to microcomposites. It is noteworthy to mention that minute amount of nanoaterials (5 wt%) are needed to bring magical changes in the composite behaviour. Polymer nanocomposites are unique in terms of thermal stability, mechanical behaviour, toughness and barrier potential.

***Keywords*:** composites, polymer, nano nanocomposites, technological importance, industrial applications

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1. INTRODUCTION

A composite material is a new material prepared combination of two or more other materials with notable different physical or chemical properties with the characteristics different from the individual components.It is a combination of two substances with different physical and chemical properties. The new substance has certain superior properties, for instance may become stronger, lighter or resistant to electricity. They may have improved strength and stiffness. The improved properties of the composites their base materials are responsible for wide application over the traditional materials in several industries.

2. BRIEF HISTORY

Humans have used composites for thousands of years. First man made composites were engineered in 3400 B.C. The ancient people started preparing plywood by adding wood strips on top of each other by glue at several angles. Following this, people made death masks from papyrus or linen soaked in plaster. Then they started reinforcing the materials with straw to strengthen pottery, mud bricks etc. And that is the beginning of the production of man made composites. Following the industrial revolution, synthetic resins started to take a solid form by using the process of polymerization. Around twentieth century, different kinds of plastics like polyester, phenolic, vinyl etc. are prepared using the new idea of chemical synthesis. After that heat Bakelite was discovered which is highly heat resistant and non conductor of electricity and hence can be widely used across many industries. The year 1930 was an remarkable important time for the advancement of composites. Glass fibre was produced by Owens Corning who had also started working with first fibre reinforced polymer (FRP) industry. Resins engineered during that days are equally useful today and, in 1936, unsaturated polyester resins were patented. After two years, higher performance resin systems became accessible.

The interest in composite materials is increasing day by day due to their several advantages compared to metal alloys. Composites contain mainly two parts: continuous and discontinuous phases known as matrix and reinforcement. The matrix phase usually contains of metals, ceramics, or polymers whereas glass, metals, ceramics, or varieties of fibers are in general used as reinforcement material [1].

2. 1. Different types of composites

Some common composite materials include:

1) **Ceramic matrix composite:** Here ceramic fibers spread out in a ceramic matrix. These are better than normal ceramics as they are thermal shock resistant and having high value of fracture toughness.

2) **Metal matrix composite**: Here fibers or particles are dispersed metal matrix

3) **Reinforced concrete**: Here concrete is strengthened by a material like steel with high tensile strength.

4) **Glass fibre reinforced concrete**: It is a composite, consisting of portland cement, fine aggregate, water, acrylic polymer, alkali-resistant glass fiber reinforcement and additives.

5) **Translucent concrete**: This is a type of concrete produced on the concept of 'Nano Optics'. Here optical fibers act as slits and transmit light from one side of the surface to another.

6) **Engineered wood**: It a product that is manufactured by mixed with several percentage of shredded wood fibres, sawdust, adhesives and various chemicals to look like wood. One example is praticle board. A special material like veneer will also falls under this category.

7) **Plywood**: A special type of wood is febricated by gluing many thin layers of wood together at different angles.

8) **Engineered bamboo**: Composite prepared from raw bamboo calm . Here strips of bamboo fibre glued together to make a board. This type of composites are highly compressive, have high value of tensile and flexural strength compared to wood and hence are highly useful.

9) **Parquetry**: A square of many wood pieces arranged in a geometrical pattern specially for flooring and furniture. As a decorative item it has an extensive use.

10) **Wood-plastic composite**: Composites made of Either wood fibre or wood flour cast in plastic [polythene (PE) / polypropylene (PP) / polyvinyl chloride (PVC) / polylactic acid (PLA)].

11) **Cement-bonded wood fibre**: Mineralized wood pieces cast in cement. This composite has both insulating and acoustic properties.

12) **Fibreglass**: Glass fibre combined with a plastic composed of woven material which is relatively inexpensive and flexible

13) **Carbon Fibre reinforced polymer**: Carbon fibre set in plastic which has a high strength-to-weight ratio

14) **Sandwich panel**: A variety of composites that are layered on top of each other

15) **Composite honeycomb**: A selection of composites in many hexagons to form a honeycomb shape.

16) **Papier-mache**: Paper bound with an adhesive. These are found in crafts

17) **Plastic coated paper**: Paper coated with plastic to improve durability, example: playing cards.

18) **Syntactic foams**: Light weight materials are produced by filling metals, ceramics or plastics with microballoons. These ballons are made from either glass, carbon or plastic.

3. POLYMER

Polymers are long, repeating chains of molecules. It is a class of natural or synthetic substances formed by very large molecules, known as macromolecules. When number of simpler chemical units, known as monomers, are joined together, macromolecules are formed. Polymers are found in many living organisms and are the basis of many minerals and man-made materials.

These materials have unique properties, depending on the type of bonding and type of molecules being bonded. Some polymers, like rubber and polyesters, stretch and bend, whereas some others, like epoxies and glass, are very tough and hard.

Polymers touch almost every aspect of modern life. We cannot spend a day without using at least one polymer made product in a day.

The term ‘polymer’ is normally used to describe synthetic polymers like plastics. However, natural polymers, like rubber and wood, also exist in nature. Natural polymers are formed by simple hydrocarbon, isoprene. Natural polymers like proteins contain amino acids, nucleic acids (DNA and RNA) are polymers of nucleotides — complex molecules composed of nitrogen-containing bases, sugars and phosphoric acid, for example.

Polymerization is the method of producing synthetic polymers by joining monomers into a chain by covalent bonds [2]. Various chemical reactions, may be caused by heat and pressure, nalter the chemical bonds that hold monomers together. The process causes the molecules to bond in a linear, branched or network structure, resulting in polymers.

These chains of monomers are also called macromolecules. Most polymer chains have a chain of carbon atoms as a backbone. A single macromolecule can consist of hundreds of monomers.

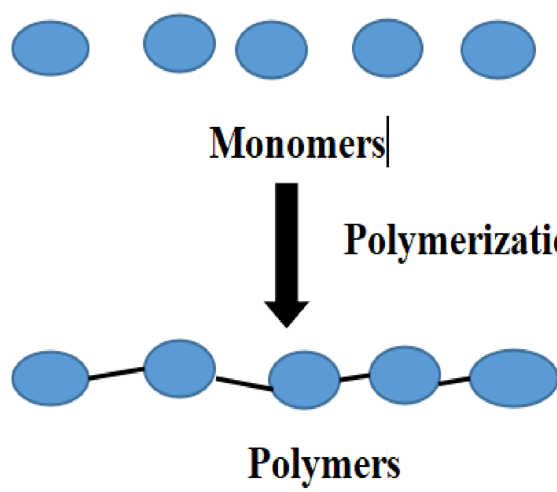

Figure 1. Polymerization

3. 1. Polymer composite

In the past few decades, the use of polymers either as matrix or reinforcing agents has been increased in a rapid rate. The increasing environmental pollution and reduction of natural resources like coal, oil, and gas have led the scientists to shift their research towards renewable products and biological feed stocks. At present, because of more strict legislation imposed by the government, most manufacturers are looking towards greener and environmental-friendly alternatives for conventional polymers and composites. Among the different renewable resources, wood is an important abundantly available resource [3]. Two types of wood are available, hard and soft wood. But, hard woods are not abundant due to over use. Therefore, a continuous trial is running to produce better quality soft woods, modifying it chemically, without compromising the properties. The performance of wood is enhanced by forming composite of wood and polymer and it is known as wood polymer composite (WPC).

A polymer composite is a multi-phase material in which reinforcing fillers are embedded in a polymer matrix. A polymer matrix composite (PMC) is a composite material composed of a number of small or continuous fibers bound together by an organic polymer matrix. PMCs are designed to transfer loads between fibers of a matrix. In general, polymer composites are light weight, high strength along the direction of their reinforcements, having high stiffness constant,good abrasion resistance, good corrosion resistance etc.

3. 2. Structure

In general, polymer composite contains two phases: Fibre and matrix.

(i) Fibre: The fiber is commonly used as glass, but sometimes Kevlar, carbon fiber, or polyethylene are also used.

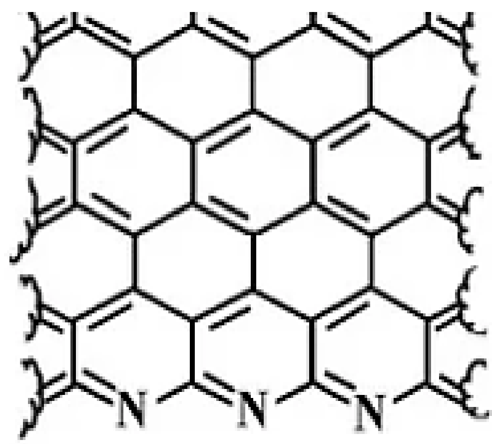

Figure 2. Structure of Carbon fibre [4]

(ii) Matrix: The matrix is a thermoset. It has symmetry with an epoxy resin, polydicyclopentadiene, or a polyimide. The properties of the matrix determines the resistance of the PMC to processes like impact damage, water absorption, chemical attack, and high-temperature creep. The matrix is made stronger by embedding fibers in it. Fiber-reinforced composites have two benefits. They are strong but light, usually stronger than steel. Hence, composites are used to make automobiles lighter, and thus more fuel efficient. As a result they pollute less, too.

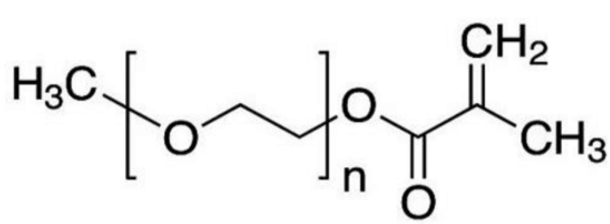

Figure 3. Structure of Polyethylene [5]

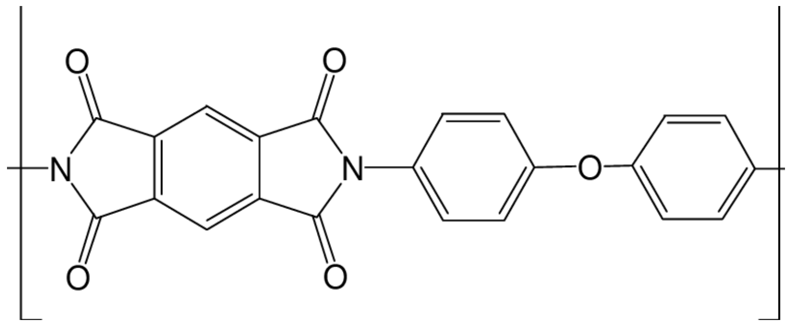

Figure 4. Chemical structure of a polyimide [6]

Several properties of the composites are improved using different cross-linkers, plasticizers, blowing agents, and nanofillers, etc. Plant fibers are in general suitable to reinforce Plastic is in general reinforced by plant fibers as they are eco-friendly, having relative high strength and stiffness and low cost. Bio based polymers have been extensively used as matrix in the manufacturing of both bio-based composites and conventional composites. The natural polymers like starch, gluten, chitosan (CS), and vegetable oils are the polymers currently used for the preparation of natural polymer-based nano composites.

The performance of polymer composites is normally depends on:

a. The properties of the fiber,

b. The properties of the polymer matrix,

c. The ratio of the fiber to the polymer matrix in the composite (fiber volume fraction), and

d. The geometry and orientation of the fiber in the composite.

The performance of a polymer composite is usually referred to their mechanical properties. It is considered to be the most important of the physical and chemical properties these type of materials.

Mechanical properties of composites are strongly influenced by the: (i) size of the fibre, (ii) type of the fibre, (iii) concentration of the fibre in the matrix, (iv) dispersion of reinforcing agent (filler), (v) interfacial tension between the matrix and filler.

3. 3. Classification of polymer composites

Polymer composites can be classified into two categories:

1) Classification according to their source:
a. Fibre-Composites
b. Natural-Fibre Composites
c. Bio-Composites

2) Classification according to polymer matrix
a. Thermoplastic
b. Thermoset
c. Rubber

3. 3. 1. Classification according to their source

Fibre-Composites / fiber-reinforced composite (FRC)

FRC is high-performance fiber composite. It can be prepared by cross-linking cellulosic fiber molecules with resins in the FRC material matrix through an appropriate molecular re-engineering, thereafter yielding a product of exceptional structural properties [7]. Selected physical and structural properties of wood are successfully cloned and vested in the FRC product by this unique method of molecular rearrangement where the yield performance properties are superior to contemporary wood. There is an advantage of recycling of the newly developed composite materials which can be recycled up to 20 times, getting the benefit of reusing of scrap FRC again and again. This is a major advantage of FRC over normal wood.

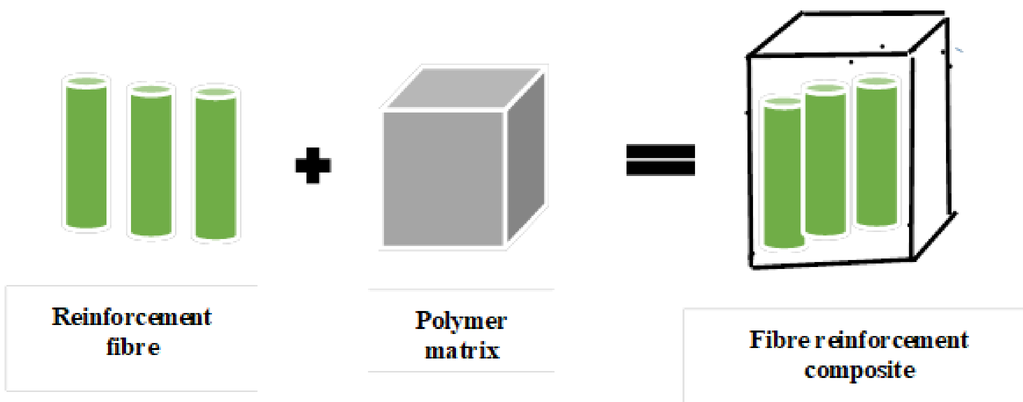

Figure 5. FRC

Natural-Fibre Composites (NFC)

NFCs are composite materials, in which the reinforcing fibres are derived from renewable resources or and carbon dioxide containing neutral resources such as wood or plants. Natural fibre composites could be 100% biodegradable. Natural fibers are biologically and environmentally durability which may considered as key advantage of them traditional materials.

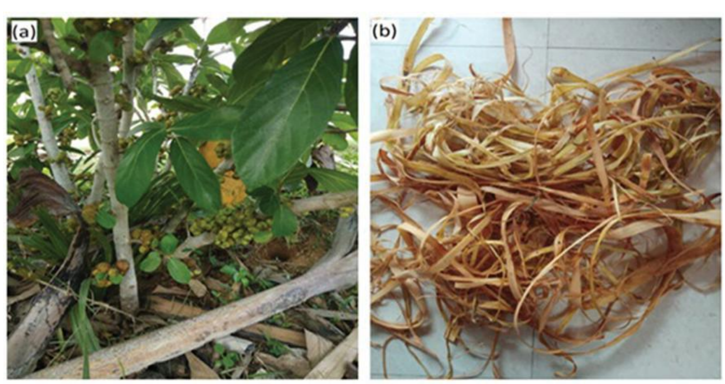

Figure 6. (a) *Ficus carica* plant, (b) *Ficus carica* fiber [8].

Bio-Composites

A biocomposite is a composite material formed by mixing resin as a matrix and natural fibers as reinforcement [7]. In this type of material, strengthening properties of matrix are used remembering the quality of biocompatilibity. Here the matrix phase is formed by polymers derived from renewable and nonrenewable resources. Biocomposites are divided into two parts: non-wood fibers and wood fibers, but cellulose and lignin are present in both the cases. Actually biofibers are the major components of biocomposites. These are derived from biological origins like fibers from crops (cotton, flax or hemp), recycled wood, waste paper, crop processing byproducts or regenerated cellulose fiber (viscose/rayon).

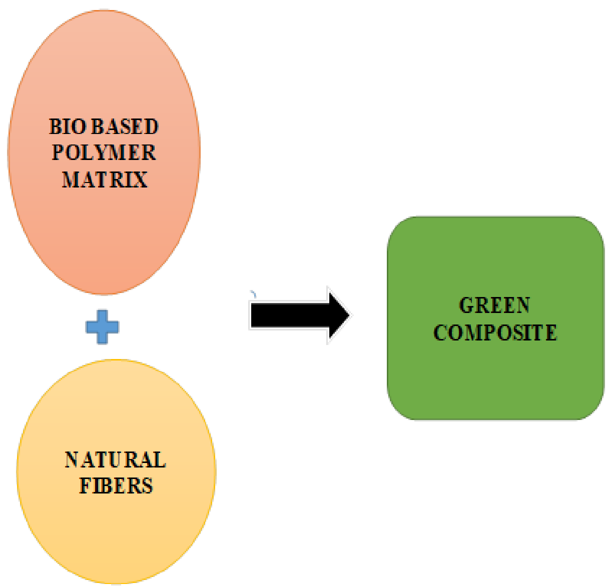

Figure 7. Bio-Composites

3. 3. 2. Classification according to polymer matrix

Thermoplastic-composites (TMC)

TMCs evolved from structural polymer composites. These materials are not chemically instability as they use a thermoplastic matrix. On heating, TMCs soften and can be remolded without degradation. On cooling, they solidify into a final shape. This multiple cyclic heating-cooling process gives the product an almost indefinite shelf life. Thermoplastic composites could also be shaped using techniques derived from wood and metalworking. These composites have enhanced recycling property and damage tolerances due to the tough nature of the matrix material. Thermoplastic composites could be categorized into either Glass Mat Thermoplastics (GMT) or Advanced Thermoplastic Composites (ATC).

Thermoset-composites

Thermoset composites are commonly based on glass, carbon or aramid fibers by the incorporation of resins such as polyesters, vinyl esters, epoxies, bismaleimides, cyanate esters, polyimides or phenolics. The recycling options for thermoset composites are limited [10].

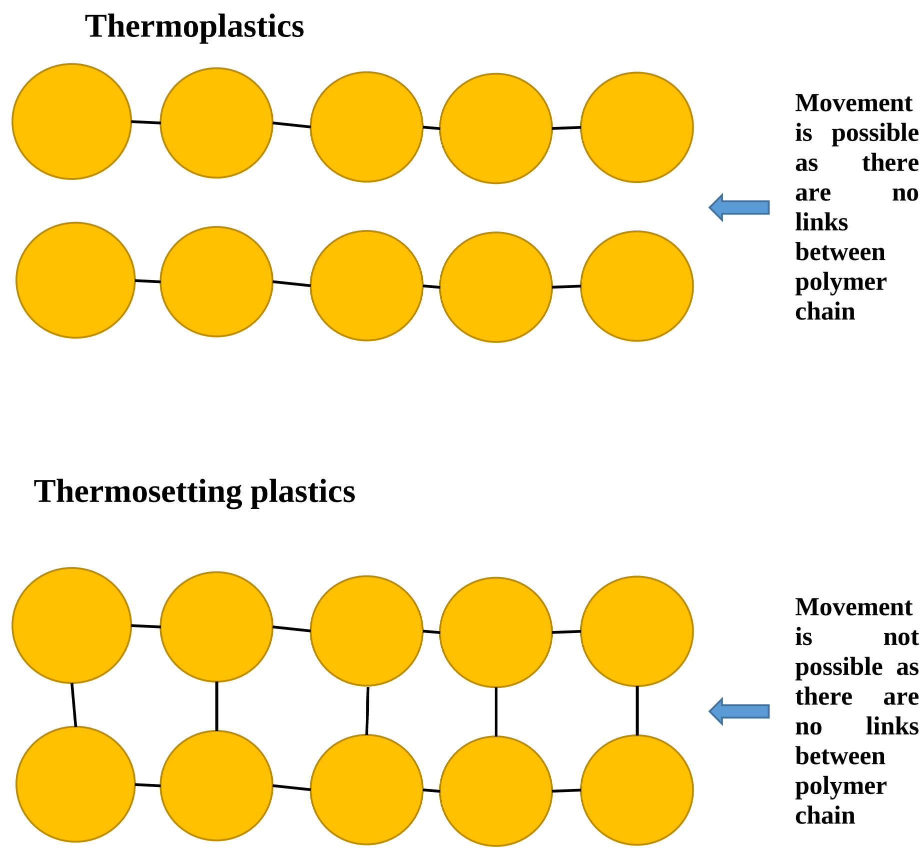

Figure 8. Thermoset-Composites

Rubber-cimposites

In rubber composites, a reinforcing material is added to rubber matrix to achieve high value of strength to flexibility ratio. A special kind of fibre is used as a reinforcing material, to provide the desired strength and stiffness. The rubber matrix, with low strength and stiffness, provides air-fluid tightness and supports the reinforcing materials to maintain their relative positions. These positions are of great importance which has the influence on the mechanical properties.

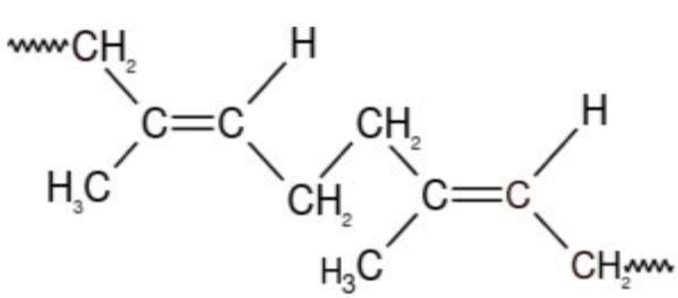

Figure 9. Natural Rubber-Composites [11]

4. NANOMATERIALS

Nanomaterials are chemical substances or materials that are manufactured and used at a very small scale. In general, they exhibit novel characteristics compared to the same material without nanoscale features, such as increased strength, chemical reactivity or conductivity. In general, material with any external dimension in the nanoscale (ranging from approximately 1 – 100 nanometers, nm) or having internal structure or surface structure in the nanoscale, are known as nanomaterials.

When particle dimension are about 1–100 nm (where the particles can be seen only with powerful specialized microscopes), the materials' properties change significantly from those at larger scales, such as melting point, fluorescence, electrical conductivity, magnetic permeability, and chemical reactivity. These change in the properties are a function of particle size.

In this nano scale, quantum effects rule the behavior and properties of particles. Nano materials have larger surface areas compared to similar masses of macroscale. When the surface area per mass of a material increases, a larger amount of the material can come in contact with surrounding materials, thus affecting the reactivity. Greater surface area of nanomaterial improves the reactivity which has helped to create better catalysts.

Nanomaterials are in general used in clothes, cosmetics, cleaning products, electronics, toys, medicines, golf balls. There are lots of different kinds of nanomaterials – some are made from gold, or silver, or titanium. Silver-based nanomaterials can have amazing antibiotic properties and are now used in special cloths having less bad smell. Gold-based nanomaterials have a ton of potential for exciting medical applications because they can be used to transport drugs to particular parts of the body or even help to detect cancer. There are also other types of nanomaterials, which are more useful for solar cells because they can absorb the energy from sunlight well. Human body is also a store house of nanomaterials. Hemoglobin is a protein that carries oxygen through the body. It has diameter in the range of 5.5 nm. A strand of DNA, one of the building blocks of human life, is only about 2 nanometers in diameter.

5. NANOCOMPOSITE

A nanocomposite is a multiphase solid matetials where one of the phases has one, two or three dimensions less than 100 nm, or structures having nano-scale repeat distances between different phases that make up the material [12]. The materials like porous media, colloids, gels and copolymers may also be used for this purpose. Actually nanocomposite is a solid combination of a bulk matrix and nano-dimensional phase(s) differing in properties due to dissimilarities in structure and chemistry. The electrochemical, mechanical (bulk modulus, strength etc.), electrical, thermal, optical, catalytic properties of the nanocomposite will differ markedly from that of the component materials.

Nanocomposites can be classified based on presence or absence of polymers in the composites [13]:

(i) Non-polymer based nanocomposites

and

(ii) Polymer based nanocomposites

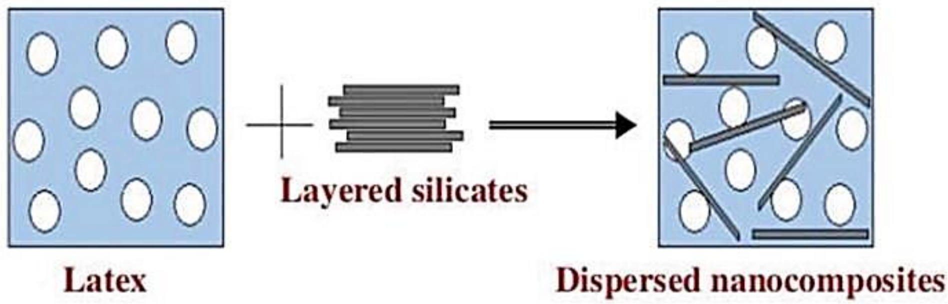

Figure 10. Formation of nanocomposite [13]

5. 1. Non-polymer based nanocomposites

Nanocomposites which do not contain any polymer or polymer derived materials are known as inorganic nanocomposites. Inorganic nanocomposites are of three types: (a) ceramic based nanocomposites, (b) metal based nanocomposites and (c) ceramic ceramic based nanocomposites.

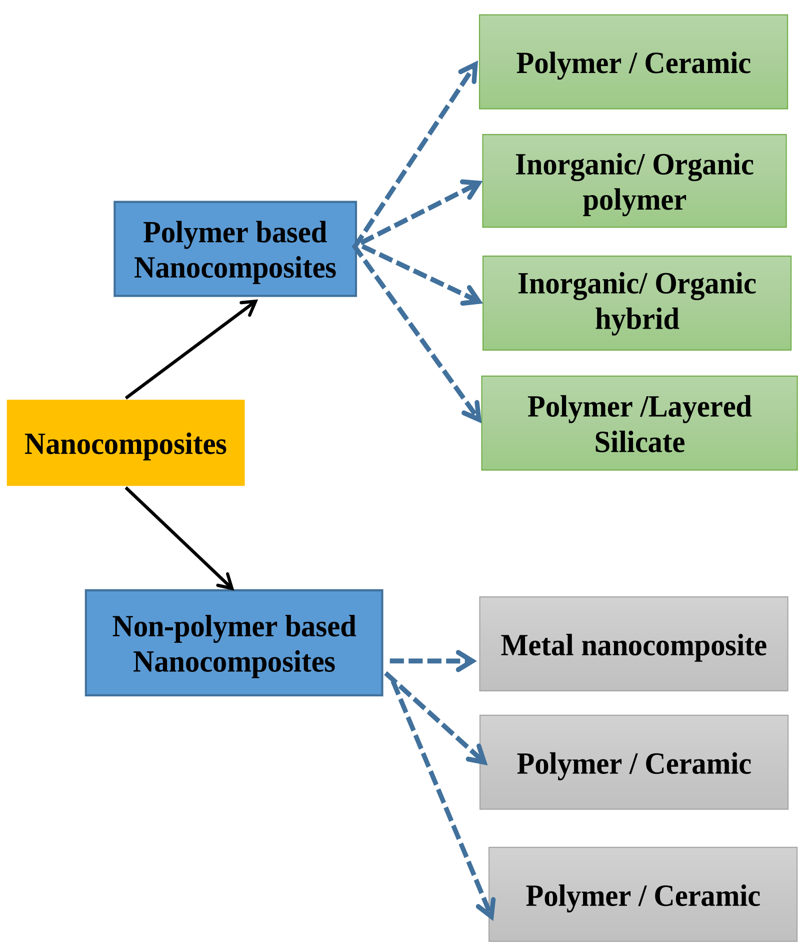

Figure 11. Classification of nanocomposites

Ceramic based nanocomposites (CMNSC)

CMNCs are multiphase solid systems having one of the constituent phases below 100 nm. Here the introduction of nanomaterials (graphene, carbon nanotubes etc.) is acting as a nano-reinforcements which has modified the ceramic-structures at the nanometric level for advanced applications in fields such as automotive, industrial, and aerospace engineering [14]. They have increases strength, increases ductility, higher hardness and better toughness. The ceramic nanocomposites have been broadly defined as a ceramic nanophase in a ceramic matrix, or to encompass a metal as the second component in ceramic matrix [16].

Metal based nanocomposites

They are composed of a ductile matrix and hard nano particle reinforcement. Nano materials replace the macro and micro sized reinforcement materials in metal matrix composites to improve the properties of the materials [15]. They are characterized by increased strength and hardness, lower melting point, improved magnetic property, super plasticity, decreases.

5. 2. Polymer based nanocomposites

Nanoparticles or nanofillers dispersed in polymers or co-polymer matrix is termed as Polymer based nanocomposites. Here atleast on of the dimensions having the shape of platelets, spheroids or fibre will be in the range of 1-50 nm. They are of four types: (a) Polymer/ceramic nanocomposites, (b) Inorganic/Organic polymer based nanocomposites, (c) Inorganic/Organic hybrid polymer based nanocomposites and (d) Polymer/layered silicate based nanocomposites.

Polymer/ceramic nanocomposites

These are a novel class of composite materials in which a nanosized clay or filler is added to a polymer matrix in a very small ratio. When dispersed in the nanocomposites at less than 5%, clay causes significant enhancement in various properties such as mechanical, optical, magnetic barrier, and specially permeability and flammability resistance [17].

Inorganic/organic polymer based nanocomposites

These are generally organic polymer composites with inorganic nanoscale building blocks. They have the combined the advantages of the inorganic material (eg., rigidity, thermal stability) and the organic polymer (eg, flexibility, dielectric, ductility, and processability). Inorganic metal oxide/conducting polymer composites have become very important for their use as energy storage devices such as batteries and supercapacitors. Metal oxides owing to their various oxidation states and low cost have become potential materials for supercapacitor electrodes [18].

Inorganic/organic hybrid polymer based nanocomposites

They are solid composite materials formed by the combination of two or more simple materials that develop a continuous phase (polymer, metal, ceramic, etc.), and a dispersed phase, such as glass fibres, carbon particles, silica powder, clay minerals, etc. In addition their properties that are totally different from the components taken separately. Within the vast collection of organic–inorganic hybrid materials, nanocomposites are the most important emerging group that received a great deal of attention not only because of their potential in industrial applications but also from their fundamental point of view [19].

Polymer/layered silicate based nanocomposites

In a polymer nanocomposite when the filler has two finite dimensions in the mictrometer range of micrometers, whereas the third dimension is in nanometer scale. Fillers are normally layered silicate (or aluminosilicate) [20].

6. POLYMER NANOCOMPOSITE

Polymer nanocomposites can also be classified into three different categories namely zero-dimensional, one-dimensional and two-dimensional polymer nanocomposites. Metal oxides (Fe_2O_3, CuO, ZnO, TiO_2 etc.), spherical nanoparticles of metals (Au, Ag, Cu, Fe, etc.) and quantum dots (CdS, CdSe, SnTe, ZnS, etc.) are the examples of zero-dimensional nanomaterials. Examples of one-dimensional nanomaterials are carbon nanofibers, carbon nanotubes, polyaniline nanofibers, cellulose nanofibers and nanowhiskers. Similarly layered silicates, nanoclay and graphene based materials are the most widely investigated two-dimensional nanomaterials [21].

6. 1. Preparation of polymer nanocomposites

While preparing polymer nanocomposites following points are needed to be addressed: (1) chemical structure of polymer; (2) polymer mass; (3) chemical solubility of polymer; (4) polymer thermal stability; (5) semi-crystallinity of polymer; (6) nanoparticle chemical structure; (7) nanoparticle surface area; and (8) dispersion of nanoparticle. Among all the methods of preparation of polymer nanocomposites few popular ones are: solution dispersion, in situ polymerization and melt extrusion.

Solution dispersion

Solvent casting method is one of the oldest methods for the preparation of polymer nanocomposites. It needs simple equipment and is less time consuming. Here the solvent must be less toxic like chloroform, acetone, water or alcohol and nanoparticles with several proportions and different sizes can be dispersed well in the polymer matrix. This is the simplest method to obtain polymer nanocomposites. Here the polymer is dissolved in water or any other non volatile solvent and nanofillers are mixed with the solution with constant vigorous stirring.

The solution is then casted on a flat surface. The solvent phase is removed by evaporation, remains and thereafter the dried film is released from the substrate and collected containing the intercalated/exfoliated structure.

This process involves the nano-filler dispersion in the polymer solution through energetic agitation, controlled solvent evaporation, and finally casting of composite film [22].

Polymerization can be initiated by heat or radiation, by the diffusion of a suitable initiator, or by an organic initiator or catalyst fixed through cation exchange inside the interlayer before the swelling step [23].

In situ polymerization

There are two types of polarization namely in situ intercalative polymerization and in situ formation and sol-gel.

In situ intercalative polymerization

This is a very good method for the preparation of polymer clay mineral hybrids and was used for the first time to synthesize polymer clay nanocomposites based on nylon 6. Here, the layered silicate is swollen within the liquid monomer solution so that polymer is formed between the intercalated sheets.

In situ formation and sol-gel

It is a method of preparation of a layered structure of inorganic material in an aqueous solution containing the polymer. Here normally water-soluble polymers are used as template for layer formation. This method is globally used for the synthesis of layered double hydroxides (LDH) nanocomposites. For the formation of layered structures following steps are to be followed:

- ✓ embedding of monomers and organic molecules on sol-gel matrices
- ✓ introduction of organic groups by formation of chemical bonds, leading to in situ formation of a sol-gel matrix within the polymer and/or simultaneous generation of inorganic/organic networks.

The sol-gel method is normally be used for synthesis of ceramics as a molding material or as an intermediate between thin films of metal oxides in several applications. The materials obtained by this method can be used in various optical, electronic, energy, surface engineering, biosensors, and pharmaceutical and separation technologies (such as chromatography).

This method is a conventional industrial method for the synthesis of nanoparticles with different chemical composition [24].

Melt extrusion/melt blending

The melt extrusion process consists of melting the polymer pellets mixing with the desired amount of the intercalated clay using banbury or an extruder through a combined process of application of heat and friction. This molten polymer is then forced under high pressure through a small orifice or, more typically, a “shower head” of orifices called a spinneret. Normally the process is carried out in inert gas ambience in presence of neon, helium, nitrogen etc. Alternatively, the polymer may be dry-mixed with the intercalant, heated in a mixer and subjected to shear sufficiently to form the desired clay polymer nanocomposites.

This process is environmentally friendly due to the absence of organic solvents. Melt blending is compatible with current industrial processes, such as extrusion and injection molding. Due to its potential application in industrial field, the melt blending process has become very popular now a days [22].

6. 2. Properties of polymer nanocomposites

Hence, it is found among all the types of composites, polymer nanocomposites have captured attentions of the scientists and engineers because of their wide range of applications with unprecedented flexibility and improvements in their physical properties. It has the characteristics like ability of film formation, enhanced functionality, dimensional variability that made them beneficial in today's society [25]. Some novel characteristics have been developed in nanocomposites over normal composites.

They posses

- ✓ improved mechanical properties (e.g. strength, modulus and dimensional stability)
- ✓ optical transparency
- ✓ improved thermal stability and heat distortion temperature (HDT)
- ✓ enhanced barrier properties,
- ✓ reduced thermal expansion coefficient
- ✓ improved flexibility
- ✓ new electrical properties (higher electrical conductivity) etc.

6. 3. Applications of nanocomposites

Nanocomposites have applications in various fields:

i) Nanocomposites are used in the field of automotive, aerospace, defense, and bio-medicine.
ii) These are also used in food packaging, specially for cheese, meat and dairy products.
iii) These are also used in blood collection tubes, drinking bottles, baby pacifiers
iv) allow design and characteristic choices that are impossible with conventional composites.
v) nanocomposites are used to produce comfortable textiles owing to their light weight and multi-functionality
vi) they are also used in sensors, actuators, mediators, biosensors, thermoregulation and energy storing devices.
vii) polymer/metal nanocomposites with microorganisms' resistance properties are often used for foodborne diseases and controlling and preventing bacteria [26].
viii) Polymer nanocomposites are potentially utilized for dental treatment [27], drug delivery [28], MRI [29], bone tissue engineering [30] etc. They are also used in in capacitors and super capacitor, lithium-ion batteries, solar cells [31-34].
ix) They have lots of environmental applications such as organic pollutant degradation, pollution adsorption, waste water treatment via membrane technology, manufacturing of electrochemical and biosensors, sensors of gases, metal ions and DNA [35-39].

7. CONCLUSION

Composite materials are unique in the sense that they can be modified according to the need of technological applications. Nowadays they become good alternative to the conventional materials owing to their exceptional physical, chemical, thermal, mechanical and electrical properties. This review article has provided a good review of composite materials explicitly polymer nano composites.

The potential and promising applications of polymers nanocomposites in various sectors of research and industries are increasing interests of different sectors of the society.

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