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A Review on Nanocomposites

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ABSTRACT

The term "nanocomposites" has greatly widened to include a wide range of systems, including one-dimensional, two-dimensional, three-dimensional, and amorphous materials, made of clearly different components and combined at the nanoscale scale. This study provides a thorough definition of nanocomposites, along with information about their history, types, characteristics, uses, and prospects. The particle size <100nm is the result-oriented in these properties. The nano-sized clay platelets interact with polymers in distinctive ways when the right compatible chemicals are used. The study demonstrates that rigid containers and films for both food and non-food applications are available for packaging. Numerous automotive and industrial components that make use of lightweight, impact-resistant, scratch-resistant and increased heat distortion performance qualities can be thought of in the context of engineering plastics. The advantages of nanocomposites over traditional ones in plastics go beyond strength. The study demonstrates that rigid containers and films for both food and non-food applications are available for packaging. Numerous automotive and industrial components that require lightweight, impact-resistant, scratch-resistant, and increased heat distortion performance qualities can be a context of engineering plastics.

INTRODUCTION

The controlled manipulation of materials with at least one dimension less than 100 nm is referred to as "nanotechnology." The goal of this technology is to combine chemistry, physics, biology, and materials science to create new material qualities that can be used to design simple methods for the manufacture of items for biomedicine, consumer goods, high-performance materials, and electrical gadgets. The Commercialization of nanotechnology is anticipated to accelerate overall technical growth and raise living standards, and personal and societal advantages everywhere.

Over the years, the definition of a nano-composite material has greatly expanded to include a wide range of systems, including amorphous materials, one-, two-, and three-dimensional systems manufactured at the nanoscale scale from materials that are distinctly different from one another. As said by 'Azonano' (2009). (11)

Materials with a nanoscale structure called nanocomposites "enhance the macroscopic qualities of products". He noted that most nanocomposites are composed of clay, carbon, polymers, or mixtures of these components with the components of nanoparticles.

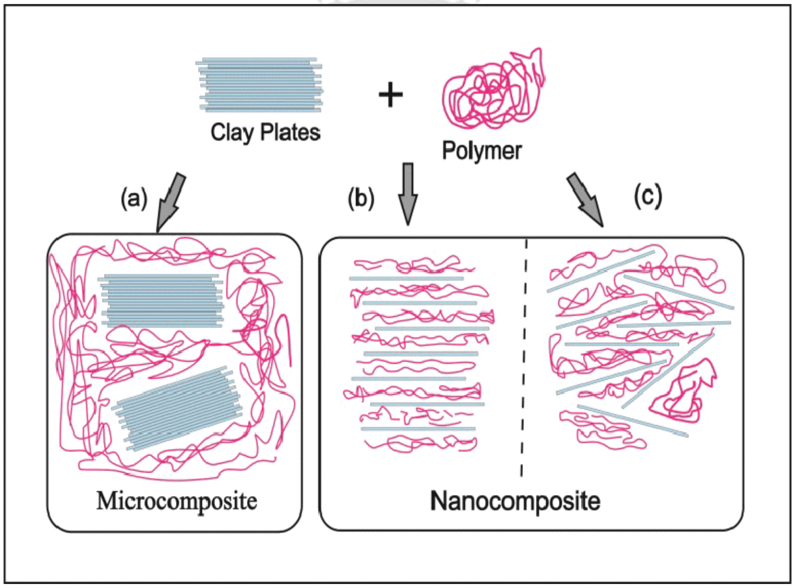

Fig:1. Picture showing microcomposites & nanocomposite

"The best characteristics of each component can then be obtained by combining one or more independent components to create nanomaterials called nanocomposites". Clay, metal, and carbon nanotube nanoparticles act as fillers in a matrix, typically a polymer matrix, in a nanocomposite.

TYPES OF NANOCOMPOSITES:

Nanocomposites are categorized based on the matrix materials as follows:

· Ceramic Matrix nanocomposites (CMNC)

· Metal Matrix nanocomposites (MMNC)

·Polymer matrix nanocomposites (PMNC)

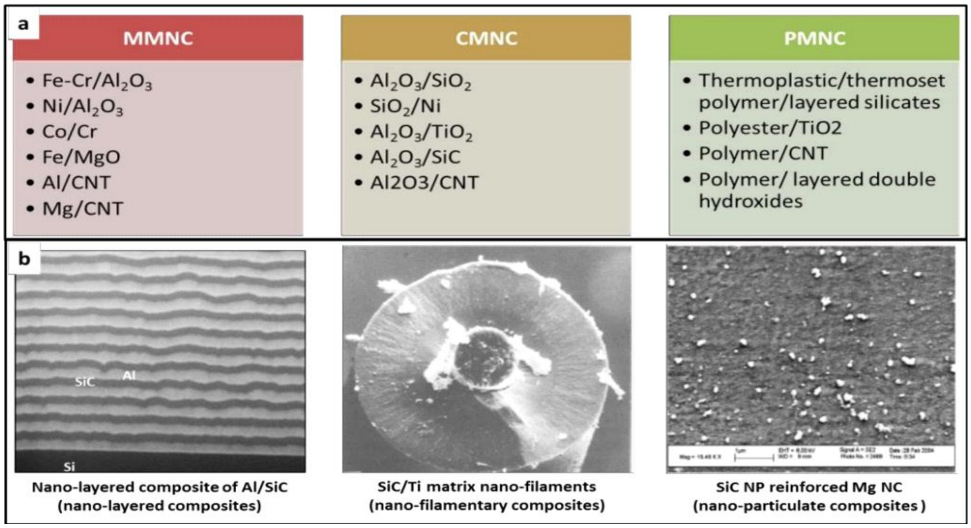

Fig:2. Types of nanocomposites.

Al_2O_3 or Sic are the major components of ceramic matrix nanocomposites (CMNC). The majority of investigations that have been published thus far have indicated that the Al_2O_3 matrix is noticeably strengthened following the addition of a low (i.e., around 10%) volume fraction of Sic particles of acceptable size and hot pressing of the resulting mixture.

Metal Matrix Nanocomposites (MMNC) are materials made of a ductile metal or alloy matrix with reinforcing elements implanted at the nanoscale. These substances mix ceramic and metal properties.

Due to their low cost of manufacture, lightweight, and ductility, Polymer Matrix Nanocomposites (PMNC) are frequently used in industry. They differ from metals and ceramics in that they have lower strength and modulus.(2,5,10)

PREPARATION OF NANOCOMPOSITES

Zapata stated in their study that there are three ways to manufacture nanocomposites: "solution mixing, the molten state, and in-situ polymerization." They emphasized that the latter involves sandwiching a monomer and a catalyst between layers of clay, and polymerization occurs as a result of place in the void such that as polymerization advances, the distance between the layers of clay gradually rises and the clays dispersion state shifts from intercalated to layered silicate gallery, preserving the ordered structure exfoliated (delamination with the destruction of the clay sheet order). The benefits of this approach are:

- The one enhanced compatibility between the clay and the metallocene polymer nanocomposites.
- Improved compatibility of the clay and polymer matrix.
- Enhance clay dispersity.

Nanocomposites can also be prepared by dispersing nano clay into a host polymer at less than 5wt% levels. This process is also termed exfoliation. When nano clay is substantially dispersed it is said to be exfoliated. Exfoliation is facilitated by surface compatibilization chemistry, which expands the nano clay platelets to the point where individual platelets can be separated from another by mechanical shear or heat of polymerization.

Nanocomposites can be made utilizing both "thermoplastic and thermoset polymers", and the particular compatibilization sciences planned and utilized are fundamentally an element of the host polymer's exceptional synthetic and actual qualities. Now and again, the last nanocomposite will be ready in the reactor during the polymerization stage. For other polymer systems, processes have been developed to incorporate nano clays into a hot-melt compounding operation.

Approximately 99% of the montmorillonite must be purified as part of the initial phase in the creation of the nano clay. The clay must be given a surface treatment in the next phase.

Montmorillonite must be chemically altered to make its surface more responsive to dispersion because it is hydrophilic and generally incompatible with most hydrophobic polymers. (6)

According to Capanescu (2002), The clays are disseminated in the polymer after being chemically processed. DeGaspari(2001) found that the clays are introduced into the polymer matrix using one of two methods: “either during polymerization or by melt compounding.” This is a challenging aspect of the technology and may restrict the application of nanocomposites. Creating polymer nanocomposites becomes challenging since each polymer utilized in the dispersion process needs a unique solution. (11)

RAW MATERIAL OF NANOCOMPOSITES

While metal matrices used in MMNC are primarily Al, Mg, Pb, Sn, W, and Fe, CMNC matrix materials include Al_2O_3 Sic, Sin, etc., similar to micro composites, while PMNC uses a wide range of polymers, such as vinyl polymers, condensation polymers, polyolefins, and specialty polymers (including a variety of biodegradable molecules). In these materials, the reinforcement is typically the only component with a nanoscale dimension. Although clays and layered silicates are the most prevalent, synthetic and natural crystalline reinforcements such as Fe and other metal powders, clays, silica, TiO_2, and other metal oxides have also been used. This is because they are readily available with very small particle sizes and have well-established intercalation chemistry as well as producing better characteristics even when they are utilized at high temperatures in extremely small quantities. (1)

PROPERTIES OF NANOCOMPOSITES

Nano-composite materials' qualities are influenced by their morphology and interfacial properties in addition to those of their parents.

Nanomaterials have different physical, chemical, and biological properties from individual atoms and molecules, or general substances. The fundamental properties of materials can be controlled by making nanoparticle materials, including their color and even their magnetic and charge capacities and melting temperatures altering the chemical makeup of the components.

The surface-to-volume and aspect ratios of nanoparticles and nanolayers, which are extraordinarily high, make them ideal for use in polymeric materials. These architectures integrate the best features of each component for advanced applications, improving the mechanical and superconducting properties. (6)

In addition to the characteristics of their parents, the morphology and interfacial characteristics of nano-composite materials affect their attributes. Some nanocomposite materials maybe 1000 times stronger than the bulk component. Nanocomposite organic/inorganic materials are a rapidly growing area of study.

Nanocomposites can dramatically improve properties like:

· Mechanical properties including strength, modulus, and dimensional stability

· Electrical conductivity

· Decreased gas, water, and hydrocarbon permeability

· Flame retardancy

. Thermal stability

· Chemical resistance

DESCRIPTION

Nano-composites are substances that have one bulk phase and additional nanoscale particles placed inside it to improve the properties of the bulk phase. These tiny particles could be of one type or another a variety of methods may be employed to modify the bulk material's qualities phase. Compared to individual atoms and molecules, nanocomposites have different characteristics of bulk stuff or molecules. The qualities can be controlled by manipulating the nanoparticle's physical properties, mechanical properties, and chemical properties of the material's biological characteristics, melting point, thermal stability and magnitude qualities, color, electronic and electrical characteristics, optical characteristics, charge capacity, superconducting qualities, thermal conductivity, corrosion avoidance, and flame retardancy catalytic properties, etc.

Nanoparticles have extremely high surface-to-volume proportions, this is the primary benefit of the nanoparticles. Some nanocomposites have 1000 times better properties than their parts. Most nanocomposites are blends of organic/inorganic nanoparticles dispersed in the bulk material.

Aluminum oxide (Al_2O_3), magnesium oxide (MgO_2), and other nanoparticles are the fillers. Clays, organoclays, ceramics, bentonite, and silica oxide (SiO_2) are a few examples. The difficult task in the bulk phase as well as the nanoparticle selection regulating the nanocomposites' characteristics. The processing method of the distribution of the nanoparticles in the bulk phase, nanocomposite, dispersion, and quantity of the bulk phase of the nanofillers has a significant influence on the enhancement of the nanocomposite's characteristics. There is a very modest amount of these particles injected as weight loss as compared to traditional methods compared to the bulk phase. Materials with the same characteristics are produced, enabling this nanocomposite to act in numerous additional applications.(3,4,6,10)

The properties of nanoparticles are improved in a variety of ways. Nanocomposites made for usage at higher temperatures may also result in weight savings and can be employed in engine and auto parts. And while maintaining excellent impact performance, offer the nanocomposites an increase in flexural/tensile modulus. In addition to increasing strength while maintaining fire safety standards, nanocomposites used in flame-retardant applications can also improve wear resistance, chemical resistance, mechanical strength, and thermal resistance.

Even if the characteristics of the particle's nature also affect the ultimate property, the values of the critical particle sizes for various attributes are labeled differently. The values of the catalytic property of the particle size may be in the range of 2 to 5 nm, 100 nm for mechanical qualities and super para magnetism, 50 nm for changing the refractive index, and 20 nm for softening magnetic material.

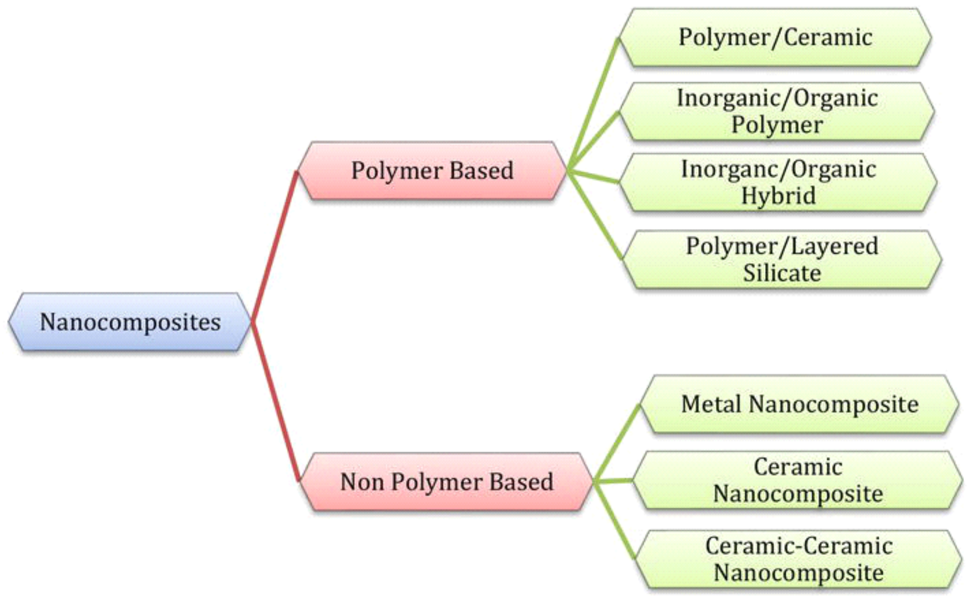

Fig:3. Classification of nanocomposites.

APPLICATIONS

Bio-medical applications: Polymer nanocomposites based on hydroxyapatite [Ca10(PO4)6(OH)2] have been investigated for bone repair and implantation. Hydroxyapatite, a major constituent of hard tissue exhibits undesirable mechanical properties if directly employed thus polymer-based matrix nanocomposites are desired. Collagen-derived gelatin and poly-2-hydroxyethyl methacrylate/poly (3- caprolactone) nanocomposites based on hydroxyapatite are examples of systems studied for bone repair systems. (1)

Fuel cell application: Nanoparticles play a major part in fuel cells. Pt nanoparticles were deposited onto single-walled carbon nanotubes with Nafion as a binder to improve performance over the conventional carbon black-based electrodes. Nanoparticle incorporation in the proton exchange membrane has been noted in numerous publications to improve mechanical properties as well as to enhance proton conductivity.

Nanosystem for drug delivery: Nanoscale drug delivery systems (5–250 nm) can change the therapy of various diseases due, first of all, to the increased ability to overcome multiple biological barriers, improve the half-life, and target drug delivery. Currently, there are five known nanotechnology platforms used for targeted drug delivery, differing in physicochemical structure: polymersomes, nanoshells, dendrimers, polymer micelles, and polymer-drug conjugates. Also, pharmaceutical manufacturers are currently using nanomaterials not only as drug carriers but as packaging material, while increasing productivity and preserving the consumer properties of the drug. Nanotechnology has enabled drug delivery systems with optimized physical, chemical, and biological properties that can serve as practical drug delivery tools currently available. Some nanocarrier systems consist of polymer nanoparticles, liposomes, dendrimers, polymer micelles, polymer-drug conjugates, and antibody-drug conjugates. (6,7)

CONCLUSION

Nanocomposites are preparations that are quite broad and diverse. This method can produce materials with many areas of material property enhancement, which can result in materials with multiple uses. To improve the numerous different sorts of qualities of the composites, we may also add two or more types of nanoparticles. The unique property of the nano-dispersed phase will change to manifolds, regardless of particle size. Material technology is undergoing a revolution thanks to this method.

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