ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 11,November 2017

Nanocomposites and Their Applications

[1] Balaji.V, [2] B.Manasa, [3] Aakash.N,[4] Chandrakaanth BS,[5] Kiran Kumar KC
[1] Asst.Professor & HOD, [2][3][4][5] UG Students
[1][2][3][4][5] Department of Mechanical Engg, Sri Sairam College of Engineering, Bangalore

Abstract:- **This paper/document gives the information regarding a brief introduction to nanocomposites, types of nanocomposites and their general applications. The idea behind Nanocomposite is to use building blocks with dimensions in nanometer range to design and create new materials with unprecedented flexibility and improvement in their physical properties. In the broadest sense, this definition can include porous media, colloids, gels and copolymers, but is more usually taken to mean the solid combination of a bulk matrix and Nano-dimensional phase(s) differing in properties due to dissimilarities in structure and chemistry. The mechanical, electrical, thermal, optical, electrochemical, catalytic properties of the nanocomposite will differ markedly from that of the component materials. Size limits for these effects have been proposed.**

INTRODUCTION

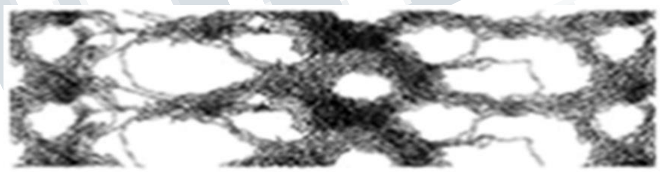
Nanocomposite is a multiphase solid material where one of the phases has one, two or three dimensions of less than 100 nanometers (nm), or structures having Nano-scale repeat distances between the different phases that make up the material.

The idea behind Nanocomposite is to use building blocks with dimensions in nanometer range to design and create new materials with unprecedented flexibility and improvement in their physical properties.

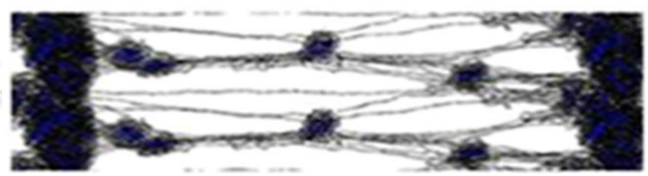
In the broadest sense this definition can include porous media, colloids, gels and copolymers, but is more usually taken to mean the solid combination of a bulk matrix and nano-dimensional phase(s) differing in properties due to dissimilarities in structure and chemistry. The mechanical, electrical, thermal, optical, electrochemical, catalytic properties of the nanocomposite will differ markedly from that of the component materials. Size limits for these effects have been proposed

<5 nm for catalytic activity,
<20 nm for making a hard-magnetic material soft,
<50 nm for refractive index changes,
<100 nm for achieving superparamagnetic, mechanical strengthening or restricting matrix dislocation movement.

Nanocomposites are found in nature, for example in the structure of the abalone shell and bone. In mechanical terms, nanocomposites differ from conventional composite materials due to the exceptionally high surface to volume ratio of the reinforcing phase and/or its exceptionally high aspect ratio. The matrix material properties are significantly affected in the vicinity of the reinforcement. Nanocomposites, properties related to local chemistry, degree of thermoset cure, polymer chain mobility, polymer chain conformation, degree of polymer chain ordering or crystallinity can all vary significantly and continuously from the interface with the reinforcement into the bulk of the matrix.



(a) Pure



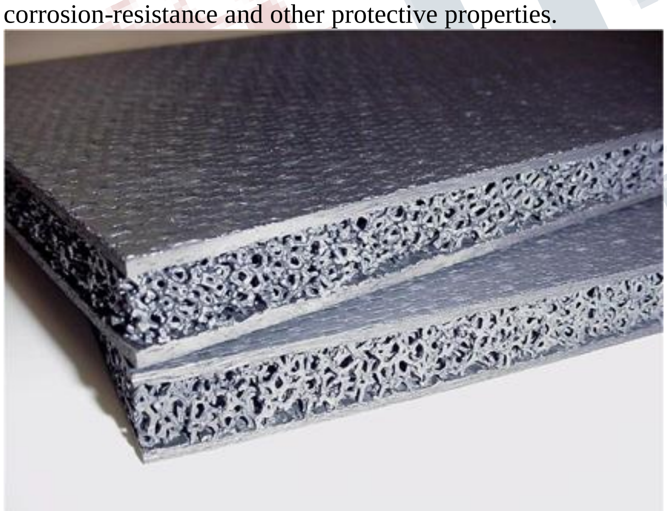
(b) polymer-graphene nanocomposites

This large amount of reinforcement surface area means that a relatively small amount of nanoscale reinforcement can have an observable effect on the macroscale properties of the composite. For example, adding carbon nanotubes improves the electrical and thermal conductivity. Other kinds of nanoparticulate may result in enhanced optical properties, dielectric properties, heat resistance or mechanical properties such as stiffness, strength and resistance to wear and damage. In general, the Nano reinforcement is dispersed into the matrix during processing. The percentage by weight (called mass fraction) of the Nano particulates introduced can remain very low (on the order of 0.5% to 5%) due to the low filler percolation threshold, especially for the most commonly used non-spherical, high aspect ratio fillers (e.g. nanometer-thin platelets, such as clays, or nanometer-diameter cylinders, such as carbon nanotubes). The orientation and arrangement of asymmetric nanoparticles, thermal property mismatch at the interface, interface density per unit volume of nanocomposite, and polydispersity of nanoparticles significantly affect the effective thermal conductivity of nanocomposites.

TYPES OF NANOCOMPOSITES

Ceramic-matrix nanocomposites

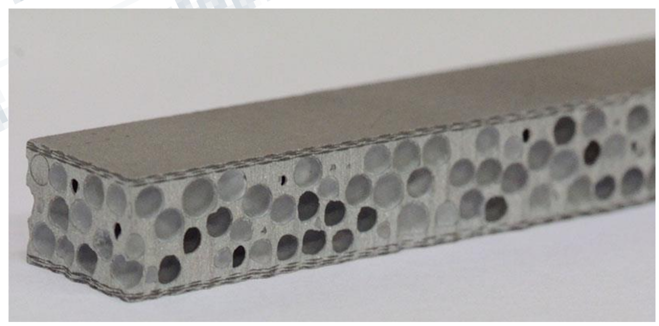
Ceramic matrix composites (CMCs) are a subgroup of composite materials as well as a subgroup of ceramics. They consist of ceramic fibers embedded in a ceramic matrix, thus forming a ceramic fiber reinforced the ceramic material. The matrix and fibers can consist of any ceramic material, whereby carbon and carbon fibers can also be considered a ceramic material. In this group of composites the main part of the volume is occupied by a ceramic, i.e. a chemical compound from the group of oxides, nitrides, borides, silicide's etc.. In most cases, ceramic-matrix nanocomposites encompass a metal as the second component. Ideally, both components, the metallic one and the ceramic one, are finely dispersed in each other in order to elicit the particular nanosomic properties. Nanocomposite from these combinations were demonstrated in improving their optical, electrical and magnetic properties as well as tribological, corrosion-resistance and other protective properties.



The concept of ceramic-matrix nanocomposites was also applied to thin films that are solid layers of a few nm to some tens of µm thickness deposited upon an underlying substrate and that play an important role in the functionalization of technical surfaces. Gas flow sputtering by the hollow cathode technique turned out as a rather effective technique for the preparation of nanocomposite layers. The process operates as a vacuum-based deposition technique and is associated with high deposition rates up to some µm/s and the growth of nanoparticles in the gas phase. Nanocomposite layers in the ceramics range of composition were prepared from TiO_2 and Cu by the hollow cathode technique that showed a high mechanical hardness, small coefficients of friction and a high resistance to corrosion.

Metal-matrix nanocomposites

Metal matrix nanocomposites can also be defined as reinforced metal matrix composites. This type of composites can be classified as continuous and non-continuous reinforced materials. One of the more important nanocomposites is Carbon nanotube metal matrix composites, which is an emerging new material that is being developed to take advantage of the high tensile strength and electrical conductivity of carbon nanotube materials. Critical to the realization of CNT-MMC possessing optimal properties in these areas are the development of synthetic techniques that are (a) economically producible, (b) provide for a homogeneous dispersion of nanotubes in the metallic matrix, and (c) lead to strong interfacial adhesion between the metallic matrix and the carbon nanotubes. In addition to carbon nanotube metal matrix composites, boron nitride reinforced metal matrix composites and carbon nitride metal matrix composites are the new research areas on metal matrix nanocomposites.



A recent study, comparing the mechanical properties (Young's modulus, compressive yield strength, flexural modulus and flexural yield strength) of single- and multi-walled reinforced polymeric (polypropylene fumarate—PPF) nanocomposites to tungsten disulfide nanotubes reinforced PPF nanocomposites suggest that tungsten disulfide nanotubes reinforced PPF nanocomposites possess significantly higher mechanical properties and tungsten disulfide nanotubes are better reinforcing agents than carbon nanotubes. Increases in the mechanical properties can be attributed to a uniform dispersion of inorganic nanotubes in

ISSN (Online) 2456-1290

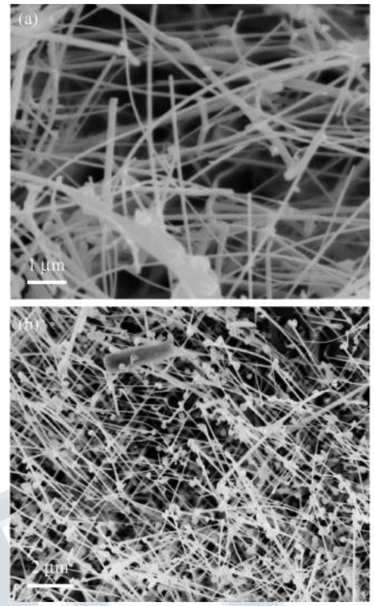
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 11,November 2017

the polymer matrix (compared to carbon nanotubes that exist as micron sized aggregates) and increased crosslinking density of the polymer in the presence of tungsten disulfide nanotubes (increase in crosslinking density leads to an increase in the mechanical properties). These results suggest that inorganic nanomaterials, in general, may be better reinforcing agents compared to carbon nanotubes.

Another kind of nanocomposite is the energetic nanocomposite, generally as a hybrid sol–gel with a silica base, which, when combined with metal oxides and Nano-scale aluminum powder, can form super thermite materials.

Polymer-matrix nanocomposites
In the simplest case, appropriately adding nanoparticulate to a polymer matrix can enhance its performance, often dramatically, by simply capitalizing on the nature and properties of the nanoscale filler (these materials are better described by the term nanofiller polymer composites). This strategy is particularly effective in yielding high performance composites, when good dispersion of the filler is achieved and the properties of the nanoscale filler are substantially different or better than those of the matrix.

Nanoparticles such as graphene, carbon nanotubes, molybdenum disulfide and tungsten disulfide are being used as reinforcing agents to fabricate mechanically strong biodegradable polymeric nanocomposites for bone tissue engineering applications. The addition of these nanoparticles in the polymer matrix at low concentrations (~0.2 weight %) cause significant improvements in the compressive and flexural mechanical properties of polymeric nanocomposites. Potentially, these nanocomposites may be used as a novel, mechanically strong, light weight composite as bone implants. The results suggest that mechanical reinforcement is dependent on the nanostructure morphology, defects, dispersion of nanomaterials in the polymer matrix, and the cross-linking density of the polymer. In general, two-dimensional nanostructures can reinforce the polymer better than one-dimensional nanostructures, and inorganic nanomaterials are better reinforcing agents than carbon based nanomaterials. In addition to mechanical properties, polymer nanocomposites based on carbon nanotubes or graphene have been used to enhance a wide range of properties, giving rise to functional materials for a wide range of high added value applications in fields such as energy conversion and storage, sensing and biomedical tissue engineering. For example, multi-walled carbon nanotubes based polymer nanocomposites have been used for the enhancement of the electrical conductivity.



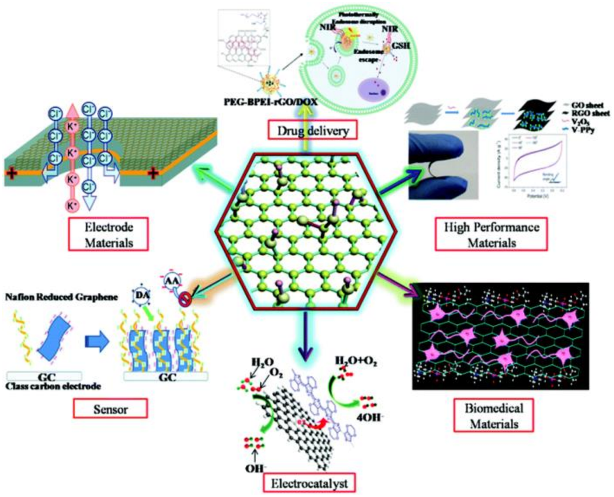
Nanoscale dispersion of filler or controlled nanostructures in the composite can introduce new physical properties and novel behaviors that are absent in the unfilled matrices. This effectively changes the nature of the original matrix (such composite materials can be better described by the term genuine nanocomposites or hybrids). Some examples of such new properties are fire resistance or flame retardancy, and accelerated biodegradability.

A range of polymeric nanocomposites are used for biomedical applications such as tissue engineering, drug delivery, cellular therapies. Due to unique interactions between polymer and nanoparticles, a range of property combinations can be engineered to mimic native tissue structure and properties. A range of natural and synthetic polymers are used to design polymeric nanocomposites for biomedical applications including starch, cellulose, alginate, chitosan, collagen, gelatin, and fibrin, poly(vinyl alcohol) (PVA), poly(ethylene glycol) (PEG), poly(caprolactone) (PCL), poly(lactic-co-glycolic acid) (PLGA), and poly(glycerol sebacate) (PGS). A range of nanoparticles including ceramic, polymeric, metal oxide and carbon-based nanomaterials are incorporated within polymeric network to obtain desired property combinations.

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 11,November 2017

The applications of nanocomposites



The following survey of nanocomposite applications introduces you to many of the uses being explored, including:

Producing batteries with greater power output. Researchers have developed a method to make anodes for lithium ion batteries from a composite formed with silicon Nano spheres and carbon nanoparticles. The anodes made of the silicon-carbon nanocomposite make closer contact with the lithium electrolyte, which allows faster charging or discharging of power.

Speeding up the healing process for broken bones. Researchers have shown that growth of replacement bone is speeded up when a nanotube-polymer nanocomposite is placed as a kind of scaffold which guides growth of replacement bone. The researchers are conducting studies to better understand how this nanocomposite increases bone growth.

Producing structural components with a high strength-to-weight ratio. For example, an epoxy containing carbon nanotubes can be used to produce nanotube-polymer composite windmill blades. This results in a strong but lightweight blade, which makes longer windmill blades practical. These longer blades increase the amount of electricity generated by each windmill.

Using graphene to make composites with even higher strength-to-weight ratios. Researchers have found that adding graphene to epoxy composites may result in stronger/stiffer components than epoxy composites using a similar weight of carbon nanotubes. Graphene appears to bond better to the polymers in the epoxy, allowing a more effective coupling of the graphene into the structure of the composite. This property could result in the manufacture of components with higher strength-to-weight ratios for such uses as windmill blades or aircraft components.

Making lightweight sensors with nanocomposites. A polymer-nanotube nanocomposite conducts electricity; how well it conducts depends upon the spacing of the nanotubes. This property allows patches of polymer-nanotube nanocomposite to act as stress sensors on windmill blades. When strong wind gusts bend the blades, the nanocomposite will also bend. Bending changes, the nanocomposite sensor's electrical conductance, causing an alarm to be sounded. This alarm would allow the windmill to be shut down before excessive damage occurs.

Using nanocomposites to make flexible batteries. A nanocomposite of cellulous materials and nanotubes could be used to make a conductive paper. When this conductive paper is soaked in an electrolyte, a flexible battery is formed.

Making tumors easier to see and remove. Researchers are attempting to join magnetic nanoparticles and fluorescent nanoparticles in a nanocomposite particle that is both magnetic and fluorescent. The magnetic property of the nanocomposite particle makes the tumor more visible during an MRI procedure done prior to surgery. The fluorescent property of the nanocomposite particle could help the surgeon to better see the tumor while operating.

CONCLUSION

This paper presented the brief introduction to nanocomposites, their types and their common applications. By the end of this paper we are now aware of the various types and applications of nanocomposites.

REFERENCES

[1] Kamigaito, O (1991). "What can be improved by nanometer composites?". J. Jpn. Soc. Powder Powder Metall. 38 (3): 315–21. doi:10.2497/jjspm.38.315. in Kelly, A, Concise

encyclopedia of composites materials, Elsevier Science Ltd, 1994

[2] Jose-Yacaman, M.; Rendon, L.; Arenas, J.; Serra Puche, M. C. (1996). "Maya Blue Paint: An Ancient Nanostructured Material". Science. 273 (5272): 223–5. PMID 8662502. doi:10.1126/science.273.5272.223.

[3] B.K.G. Theng "Formation and Properties of Clay Polymer Complexes", Elsevier, NY 1979; ISBN 978-0-444-41706-0

[4] P.M. Ajayan; L.S. Schadler; P.V. Braun (2003). Nanocomposite science and technology. Wiley. ISBN 3-527-30359-6.

[5] Tian, Zhiting; Hu, Han; Sun, Ying (2013). "A molecular dynamics study of effective thermal conductivity in nanocomposites". Int. J. Heat Mass Transfer. 61: 577–582. doi:10.1016/j.ijheatmasstransfer.2013.02.023.

[6] F. E. Kruis, H. Fissan and A. Peled (1998). "Synthesis of nanoparticles in the gas phase for electronic, optical and magnetic applications – a review". J. Aerosol Sci. 29 (5–6): 511–535. doi:10.1016/S0021-8502(97)10032-5.

[7] S. Zhang; D. Sun; Y. Fu; H. Du (2003). "Recent advances of superhard nanocomposite coatings: a review". Surf. Coat. Technol. 167 (2–3): 113–119. doi:10.1016/S0257-8972(02)00903-9.

[8] G. Effenberg, F. Aldinger & P. Rogl (2001). Ternary Alloys. A Comprehensive Compendium of Evaluated Constitutional Data and Phase Diagrams. Materials Science-International Services.

[9] M. Birkholz; U. Albers & T. Jung (2004). "Nanocomposite layers of ceramic oxides and metals prepared by reactive gas-flow sputtering" (PDF). Surf. Coat. Technol. 179 (2–3): 279–285. doi:10.1016/S0257-8972(03)00865-X.

[10] Janas, Dawid; Liszka, Barbara (2017). "Copper matrix nanocomposites based on carbon nanotubes or graphene". Mater. Chem. Front. doi:10.1039/C7QM00316A.

[11] S. R. Bakshi, D. Lahiri, and A. Argawal, Carbon nanotube reinforced metal matrix composites - A Review, International Materials Reviews, vol. 55, (2010), http:// web. eng. fiu. Edu /agar wala /PDF /2010 / 12.p

