

The Applications and Benefits of Nanotechnology in Mechanical Industries-An Overview

K. A. Swathi

M. E. (Automation and Robotics)

Lecturer in Mechanical Engineering, J. N. Govt. Polytechnic College, Ramanthapur, Hyderabad

Abstract - Nanotechnology becomes an all-embracing term, which means many things to many people. It is interface technologies that are include many different science and applications area. It falls into this category and offers fundamentally new capabilities to architect a board array of the novel materials, composites and structure on a molecular scale. Here discusses on some of the applications for nanotechnology and shows a few cases of them. That is believed to have the highest probability of success in competitive industry. The nanotechnology that are economically promising for the future include those that have applications in information technology, electronics, building materials, household appliances, textiles, cosmetics, food, environmental technologies, energy technologies and medicine etc.,

Keywords: NanoTechnology, Nanomaterials, Nanocomposite.

I. INTRODUCTION

Nanotechnology deals with studies of phenomena and manipulation with elements of matter at the atomic, molecular and macromolecular level (ranging from 1 to 100 nm), where the properties of matter are significantly different from their properties at larger scales of dimensions. Nanotechnology is science, engineering and technology conducted at the nanoscale, which is about 1 to 100 nm where nano denotes the scale range of 10^{-9} and nanotechnology refers the properties of atoms and molecules measuring thoroughly 0.1 to 1000 nm. Nanotechnology is highly interdisciplinary as a field, and it requires knowledge drawn from a variety of scientific and engineering arenas. There are two main types of approaches to nanotechnology: the first approach is Top-down and another one is Bottom-up approach. The Top-down approach involves taking layer structures that are either reduced down size until they reach the nano-scale or deacon structured into their composite parts. The other hand the Bottom-up approach is where materials are constructed from the atomic or molecular components. Designing at the nanoscale is working in a world where physics, chemistry, electrical engineering, mechanical engineering, and even biology become unified into an integrated field. "Building blocks" for nanomaterials include carbon-based components and organics, semiconductors, metals, and metal oxides; nanomaterials are the infrastructure, or building

blocks, for nanotechnology. The last decade has seen advancement in every side of nanotechnology such as: nanoparticles and powders; nanolayers and coats; electrical, optic and mechanical nanodevices; and nanostructure biological materials. Presently, nanotechnology is estimated to be influential in the next 20-30 years, in all fields of science and technology.

II. USES OF NANOTECHNOLOGY

The nanotechnology in mechanical engineering and manufacturing is immensely useful to the field. Nanotechnology can be used to increasing the life of the components and automobile parts. A many number of materials can be enhanced by the use of nanotechnology. Nanomaterials exhibit unique physical and chemical properties and impart enhancements to engineered materials. There including better magnetic properties, improved mechanical activity and increased optical properties. Developments are being made to improve the properties of the materials and to find alternative precursors that can give desirable properties on the materials.

Fundamentals Concepts in Nanotechnology

Nanotechnology involve the ability to see and to control individual atoms and molecules, everything on earth is made up of atoms the food we eat the cloths we wear the building and houses we live in, and our own bodies. Here are a few illustrative examples.

- There are 25,400,000 nanometer an inch.
- A sheet of news paper is about 100,000 nanometer thick.

The microscopes needed to see things at the nanoscale were invented relatively recently. Although modern nanoscience and nanotechnology are quite new, nanoscale materials were used for centuries. Today's scientists and engineers are finding a wide variety of ways to deliberately make materials at the nanoscience to take advantage of their enhanced properties. such as higher strength, lighter weight, increased control of light spectrum and greater chemical reactivity than their large-scale counter parts.

Nanomaterials

Nanoscale materials are defined as a set of substances where at least one dimension is less than approximately 100 nanometers. A nanometer is one millionth of a millimeter approximately 100,000 times smaller than the diameter of a human hair. Nanomaterials are of interest because at this scale unique optical, magnetic, electrical, and other properties emerge. These emergent properties have the potential for great impacts in electronics, medicine, and other fields.

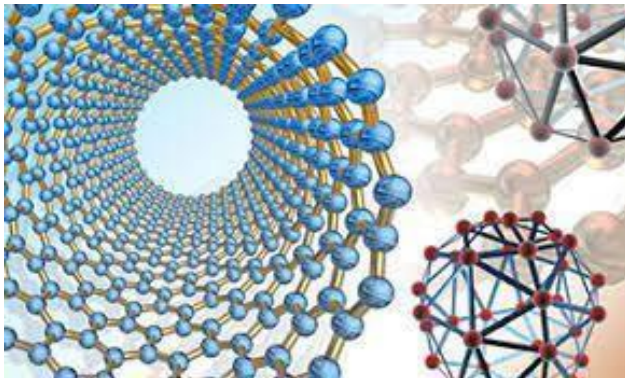


Fig.-1 Nano Material

Nanomaterials are resources designed at the molecular (nanometre) level to take advantage of their small size and novel properties which are generally not seen in their conventional, bulk counterparts. The two main reasons why materials at the nano scale can have different properties are increased relative surface area and new quantum effects.

Importance of Nanomaterials

These materials have created a high interest in recent years by virtue of their unusual mechanical, electrical, optical and magnetic properties. Some examples are given below:

- Nanophase ceramics are of particular interest because they are more ductile at elevated temperatures as compared to the coarse-grained ceramics.
- Nanostructured semiconductors are known to show various non-linear optical properties. Semiconductor Q-particles also show quantum confinement effects which may lead to special properties, like the luminescence in silicon powders and silicon germanium quantum dots as infrared optoelectronic devices. Nanostructured semiconductors are used as window layers in solar cells.
- Nanosized metallic powders have been used for the production of gas tight materials, dense parts and porous coatings. Cold welding properties combined with the ductility make

them suitable for metal-metal bonding especially in the electronic industry.

Properties of Nanomaterials

- Nanomaterials have the structural features in between of those of atoms and the bulk
- While most microstructured materials have similar properties to the corresponding bulk materials, the properties of materials with nanometer dimensions are significantly different from those of atoms and bulks materials. This is mainly due to the nanometer size of the materials which render them: (i) large fraction of surface atoms; (ii) high surface energy; (iii) spatial confinement; (iv) reduced imperfections, which do not exist in the corresponding bulk materials.
- Due to their small dimensions, nanomaterials have extremely large surface area to volume ratio, which makes a large to be the surface or interfacial atoms, resulting in more “surface” dependent material properties.

III. NANOCOMPOSITE

Nanocomposites can be made with a variety of enhanced physical, thermal and other unique properties. They have properties that are superior to conventional microscale composites and can be synthesized using simple and inexpensive techniques. Materials are needed to meet a wide range of energy efficient applications with light weight, high mechanical strength, unique color, electrical properties and high reliability in extreme environments. The term nanocomposite encompasses a wide range of materials right from three dimensional metal matrix composites, two dimensional lamellar composites and nano-wires of single dimension to zero-dimensional core-shells all representing many variations of nano-mixed & layered materials. Though various composite materials like fiberglass and reinforced plastics are now in wide use for numerous applications, there has been continued demand for novel composites with desirable properties for many other applications.

Nano-Composites – Basic Ingredients

There has been a great deal of interest in polymer nanocomposites over the last few years. There are different types of commercially available nano-particles that can be incorporated into the polymer matrix to form polymer nanocomposites. Polymer nanocomposites consist of a polymeric material (e.g., thermoplastics, thermosets, or elastomers) with reinforcement of nano-particles. Polymeric nanocomposites can be broadly classified as

- Nanoclay-reinforced composites

- Carbon nanotube-reinforced composites
- Nanofibre-reinforced composites, and
- Inorganic particle-reinforced composites.

Nanoclay-Reinforced Composites

The term clay has been understood to be made of small inorganic particles (part of soil fraction <2

mm), without any definite composition or crystallinity. The clay mineral (also called a phyllosilicate) is usually of a layered type and a fraction of hydrous, magnesium, or aluminum silicates. Every clay mineral contains two types of sheets, tetrahedral (T) and octahedral (O). For a better understanding the major clay mineral groups along with their ideal structural chemical compositions are listed in table 1.

Table 1 Major Group’s of Clay Minerals

Sl No	Group Name	Member Minerals	General Formula	Remarks
1	kaolinite	kaolinite, dickite, nacrite	$Al_2Si_2O_5(OH)_4$	members are polymorphs (composed of the same formula and different structure)
2	montmorillonite or smectite	montmorillonite, pyrophyllite, talc, vermiculite, saunonite, saponite, nontronite	$(Ca,Na,H)(Al,Mg,Fe,Zn)_2(Si,Al)_4O_{10}(OH)_2 \cdot XH_2O$	X indicates varying level of water in mineral type
3	illite	illite	$(K,H)Al_2(Si,Al)_4O_{10}(OH)_2 \cdot XH_2O$	X indicates varying level of water in mineral type
4	chlorite	(i) amesite, (ii) chamosite, (iii) cookeite, (iv) nimite etc.	(i) $(Mg,Fe)_4Al_4Si_2O_{10}(OH)_8$ (ii) $(Fe,Mg)_3Fe_3AlSi_3O_{10}(OH)_8$ (iii) $LiAl_5Si_3O_{10}(OH)_8$ (iv) $Ni,Mg,Fe,Al)_6AlSi_3O_{10}(OH)_8$	each member mineral has separate formula; this group has relatively larger member minerals and is sometimes considered as a separate group, not as part of clays

Carbon Nanotube-Reinforced Composites

Another important type of carbon filler is carbon nanotubes and nanofibres.

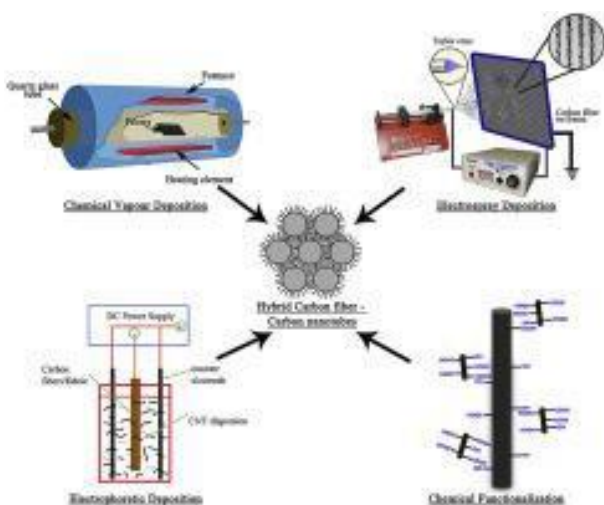


Fig-2 Structure of a multi-layer carbon nanotube

Much publicity has surrounded the development of single wall carbon nanotubes, that called Buckytubes, but while these are still some way off large-scale

commercial production, the corresponding multi-layer carbon nanotubes have been known for some time and, furthermore, are available in practical commercial quantities. The layers consist of graphitic carbon and the tubes typically have an internal diameter of 5 nm and external diameter of. 10 nm (Figure1)

Nanofiber-Reinforced Composites

Carbon nanofibers (CNF) are a unique form of vapourgrown carbon fibres that fill the gap in physical properties between conventional carbon fibres (5.10 μm) and carbon nanotubes (1.10 nm). The reduced diameter of nanofiber provides a larger surface area with surface functionalities in the fiber. Typically CNF are not concentric cylinders; the length of the fibre can be varied from about 100 μm to several cm, and the diameter is of the order of 100. 200 nm with an average aspect ratio greater than 100. The most common structure of CNF is the truncated cones, but there are wide ranges of morphologies (cone, stacked coins, etc). CNF have the morphology where these are hollow at the centre (much like a MWNT) and have a larger diameter than MWNT but the individual layers are not arranged in concentric tubes.

Inorganic Particle-Reinforced Composites

Nanoparticles are often defined as particles of < 100 nm in diameter. Nanometer-sized particles have been made from different organic, inorganic particles and these impart improved properties to composite materials. Different particles have been used to prepare polymer/inorganic particle nanocomposites, including:

- Metals (Al, Fe, Au, Ag, etc.)
- Metal oxides (ZnO, Al₂O₃, CaCO₃, TiO₂, etc.)
- Nonmetal oxide (SiO₂)
- Other (SiC)

The selection of nanoparticles depends on the desired thermal, mechanical, and electrical properties of the nanocomposites. For example, Al nanoparticles are often selected due to their high conductivity; calcium carbonate (CaCO₃) particles are chosen because of their low cost and silicon carbide (SiC) nanoparticles are used because of their high hardness, corrosion resistance, and strength.

IV. SELECTED APPLICATION OF NANOMATERIALS AND NANOTECHNOLOGY

Nanotechnology and Nanomaterials having wide range of applications in the field of energy sectors, It is evident that nanomaterials split their conventional counterparts because of their superior chemical, physical, and mechanical properties and of their exceptional formability.

Energy Sectors

The most advanced nanotechnology related to energy storage, conversion, manufacturing improvements by reducing materials and process rates, energy saving [Example: Better thermal Insulation] and enhanced renewable energy sources.

A reduction of energy consumption can be reached by better insulation systems by the use of more efficient lighting or combustion systems and by use of lighter and stronger materials in the transportation sector. Nanotechnological approaches like light-emitting diodes [LED] or quantum caged atoms [QCA's] could lead to a strong reduction of energy consumption for illumination. The solar cells have layers of several different semiconductors stacked together to absorb light at different energies but they still only manage to use 40% of the sun's energy. Nanotechnology could help increase the efficiency of light conversion by using nanostructures with a continuum of band gaps.

Corrosion Protection

Corrosion protection of metals and alloys is normally achieved by surface coatings which must resist both mechanical damage (scratching, impact, abrasion) and chemical attack (salts, acids and bases, solvents). It should also not be damaged (cracked) by having a coefficient of thermal expansion greatly different from the metal to be protected. PNCs have improved scratch and abrasion resistance, due to their higher hardness combined with improved elastic.

Sports

Nanotechnology may also play a role in sports such as soccer, football, and baseball. Materials for new athletic shoes may be made in order to make the shoe lighter (and the athlete faster). Baseball bats already on the market are made with carbon nanotubes which reinforce the resin, which is said to improve its performance by making it lighter.

V. CONCLUSION

Nanotechnology is revolutionizing the world of materials. It has very high impact in developing a new generation of composites with enhanced functionality and a wide range of applications. The data on processing, characterization and applications helps researchers in understanding and utilizing the special chemical and material principles underlying these cutting-edge polymer nanocomposites. Although Nanocomposites are realizing many key applications in numerous industrial fields, a number of key technical and economic barriers exist to widespread commercialization. These include impact performance, the complex formulation relationships and routes to achieving and measuring nanofiller dispersion and exfoliation in the polymer matrix. Investment in state-of-the-art equipment and the enlargement of core research team's is another bottleneck to bring out innovative technologies on nanocomposites.

Future trends include the extension of this nanotechnology to additional types of polymer system, where the development of new compatibility strategies would likely to be a prerequisite. Production of PVC-based systems is still some way off and challenges remain to be solved in PET nanocomposites. Additional reinforcement of clay nanocomposites by glass fiber is currently being investigated. There is also interest in the development of electrically conducting clay nanocomposites. While considerable basic research activities are currently underway at Indian academic institutions & national research labs, immediate exercises on product development-cum-demonstration should be taken up in active collaboration

with the industries in the country. The nanotechnology will positively influence the Energy, Heavy Industries and Automobile industry. Due to small size of nanomaterials their physical and chemical properties can be manipulated to improve the overall properties of convectional material. The use of nanotechnology has also helped to created more efficient and sustainable materials. The uses of steel, glass, coatings made from nanotechnology helps to protection the corrosion of the layers.

VI. REFERENCES

- [1] Kosal, M.E., 2019. The threats from nanotechnology. *Bulletin of the Atomic Scientists*, 75(6), pp.290-294.2
- [2] .Leso, V., Fontana, L. and Iavicoli, I., 2019. Biomedical nanotechnology: Occupational views. *Nano Today*, 3, 24, pp.10-14.3. Li, X., 2019. Emerging technologies, emerging knowledge: intentions to seek and share information on social media about the risks and bene- fits of nanotechnology (Doctoral dissertation).
- [3] 4.Maccorri, E., MacInnis, L.J., Connor Recio, M.A. and Lepage, T.J., 2019. Nanotechnology: Perceived Risks and Risk Management. Nasrollahzadeh, M. and Sajadi, S.M., 2019. Risks of Nanotechnology to Human Life. In *Interface Science and Technology* (Vol. 28, pp. 323-336). Elsevier.
- [4] Van Cauwenberghe, 2019. Open Access Government October 2019. Zabeo, A., Keisler, J.M., Hristozov, D., Marcomini, A. and Linkov, I., 2019. Value of information analysis for assessing risks and benefits of nanotechnology innovation. *Environmental Sciences Europe*, 31(1), p.11.
- [5] Suresh Neethirajan, Digvir Jayas. 2009. Nanotechnology for food and bioprocessing industries. 5th CIGR International Technical Symposium on Food Processing, Monitoring Technology in Bioprocesses and Food Quality Management, Potsdam, Germany.
- [6] Allhoff, Fritz; Lin, Patrick; Moore, Daniel (2010). What is nanotechnology and why does it matter? from science to ethics. John Wiley and Sons. pp. 3–5. ISBN 1-4051-7545-1.
- [7] Regan, BC; Aloni, S; Jensen, K; Ritchie, RO; Zettl, A (2005). "Nanocrystal-powered nanomotor". *Nano letters* 5 (9): 1730–3. Bibcode:2005NanoL...5.1730R. doi:10.1021/nl0510659. PMID 16159214.
- [8] Shipbaugh, Calvin. "Offense-Defense Aspects of Nanotechnologies: A Forecast of Potential Milita..."
- [9] Soutter, Will. "Nanotechnology in the Military".
- [10] Altmann, Jürgen. "Military Uses of Nanotechnology: Perspectives and Concerns".
- [11] "Defence, Weapons and The Use Of Nanotechnology In Modern Combat Equipment and Warfare Systems".
- [12] Glenn, Jerome (February 2006). "Nanotechnology: Future military environmental health considerations". *Technological Forecasting and Social Change* 73. doi:10.1016/j.techfore.2005.06.010.
- [13] American Elements Announces P-Mite Line of Platinum Nanoparticles for Catalyst Applications American Elements, October 3, 2007
- [14] Platinum nanoparticles bring spontaneous ignition, April 25, 2005
- [15] Mann, Surinder (31 October 2006). "Nanotechnology and Construction". *Nanoforum.org European Nanotechnology Gateway*. Retrieved 2 January 2012.
- [16] Nanotechnology in Construction". Retrieved 23 April 2013.
- [17] Drexler, K. Eric (1992). *Nanosystems: Molecular Machinery, Manufacturing, and Computation*. New York: John Wiley & Sons. ISBN 0-471-57547-X.
- [18] Saini, Rajiv; Saini, Santosh, Sharma, Sugandha (2010). "Nanotechnology: The Future Medicine". *Journal of Cutaneous and Aesthetic Surgery* 3 (1): 32–33. doi:10.4103/0974- 2077.63301. PMC 2890134. PMID 20606992.
- [19] "Nanoscience and nanotechnologies: opportunities and uncertainties". Royal Society and Royal Academy of Engineering. July 2004. Retrieved 13 May 2011.