Preparation and Applications of Nano Composite Materials - A Review

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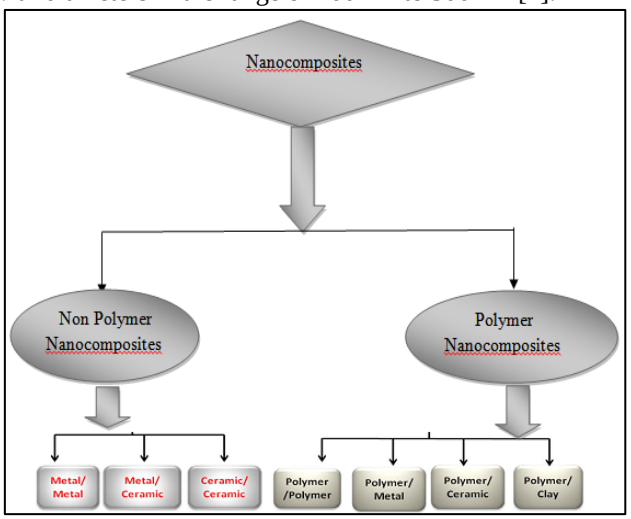
Abstract— Nano composites, a high performance material exhibit unusual property combinations and unique design possibilities. With an estimated annual growth rate of about 25% and fastest demand to be in engineering plastics and elastomers, their potential is so striking that they are useful in several areas ranging from packaging to biomedical applications. Nano composites promise new applications in many fields such as mechanically-reinforced lightweight components, non-linear optics, battery cathodes and Ionics, nanowires, sensors and other systems. This paper reviews the various preparation methods, Properties, and applications of Nano composite materials.

Key words: Nano Composites, Polymer, CNT, Nanotubes, Nanowires, SWNT

I. INTRODUCTION

Today Nano composites are currently being used in a number of fields and new applications are being continuously developed. It has been reported that changes in particle properties can be observed when the particle size is less than a particular level, called the critical size. Nano composite materials have emerged as suitable alternatives to overcome limitations of micro composites and monolithic, while posing preparation challenges related to the control of elemental composition and stoichiometry in the Nano cluster phase. Enhancement in Properties Polymer Nano composites has revealed clearly the property advantages that nanomaterial additives can provide in comparison to both their conventional filler counterparts and base polymer. In contrast to commercial available zinc oxide particles, zinc oxide nanoparticles prepared from zinc salts in alkaline medium can be solvothermally converted into one-dimensional nanostructures without any further additive. The process appears to occur via an agglomeration/ melting mechanism and leads to Nano needles of relatively large dimensions. The use of the layered hybrid Nano composite ZnO/stearic acid as zinc source instead the mixture ZnO-fatty acid as above, but using the same reaction conditions, leads to the formation of ZnO nanowires. In this case, the formation mechanism of one-dimensional nanostructures does appear to be related more to a rolling-up/surfactant-segregation process than with the characteristic ZnO crystallites growth. [1]

TiO2/ZnO composite catalysts will be applied more and more in environmental protection field and other catalytic fields. High Performance Fibre/Fabrics The first attempt to produce nanotubes resulted in very small quantities of tangled nanotubes, which however has created interest in these materials as non-oriented mats. Further developments had led to the development of techniques for spinning nanotubes into fibres in a polymer matrix, which is of special interest for mechanical and electronic fabric applications. ic fabric applications. The production of polymer fibres was until recently limited to extruding fibres of relatively large (micrometre diameter) sizes. Recently, an electro spinning technique has been shown to be effective to produce pure polymer and polymer Nano composite fibres with diameters in the range of 200 nm to 300 nm [2].



A. *Nano composite Preparation Methods*

Methods	Advantages	Disadvantages
Solution Casting [3]	Scalable	Impurity
Melt compounding	Flexible formulations	Agglomeration
Intercalation	Organized structure	Dispersion
Sol – gel[4]	compatibility	Costly, time consuming
Spinning	Interfacial interaction	Costly
Electrochemical synthesis	Synthesized under moderate conditions	Reaction on the surface only

II. PROPERTIES OF NANO COMPOSITES

- Mechanicals e.g. strength, modulus and dimensional stability.
- Improved solvent and heat resistance and decreased flammability.
- Decreased permeability to gases, water and hydrocarbons
- Thermal stability and heat distortion temperature
- Flame retardancy and reduced smoke emissions
- Chemical resistance
- Surface appearance
- Electrical conductivity
- Optical clarity in comparison to conventionally filled polymers.[5]
- Weight reduction
- Improved performance
- Aesthetics And recyclability

III. APPLICATIONS OF NANO COMPOSITES

Nano composites have been used in several applications such as mirror housings on various vehicle types, door handles, door panels, trunk liners, instrument panels, parcel shelves, head rests, roofs, upholstery and engine covers and intake manifolds and timing belt covers. Other applications currently being considered include impellers and blades for vacuum cleaners, power tool housings, mower hoods and covers for portable electronic equipment such as mobile phones, pagers etc. Starch Based Resin 11C is a biodegradable and compostable resin based on a blend of thermoplastic starch (TPS). The basic applications of the starch based resin 11C is to making Compostable bags (Shopping bags/Check-out bags, Green bin liners) and Produce and meat liners (Overwrap Packaging, Mulch film, Breathable film).[6] For non-woven fabrics to achieve electrical conductivity, a simple and flexible method has been reported, where the non-woven mat was exposed to a high intensity light source (e.g., from a flash tube), which resulted in immediate joining of fibers at cross-over points of contact. Using a mask, fibers can be joined in any desired pattern.

Nano composite materials may find wide applications in defense as electrically conductive fabrics, sensors, electromagnetic shielding, microwave absorption, electrical energy storage (capacitors), actuators, and materials for micro UAVs.

A. Ballistic Protection

There are few reports of the promising application of Nano composites in body armor. Shear thickening fluids consist of a fluid containing a dispersion of particles and this fluid stiffens and resists deformation if sheared rapidly by an external force [7].

B. Microwave Absorbers

Nano composites as microwave absorbers are receiving much attention. Polypyrrole Nano composites containing iron oxides (g and a), tin oxide, tungsten oxide and titanium dioxide. Pyrrole containing a dispersion of nanoparticle metal oxides was polymerized.[8] The electrical conductivity and dielectric losses can be tuned by varying the concentration and orientation of the nanotubes additions. Only a few weight per cent of nanotubes need be added to the polymer to achieve useful properties. Efforts have been made to utilize CNTs for developing economical microwave (in the range 8 GHz to 24 GHz) absorbers. These materials have wide applications in electrical energy storage
Refractive Index Tuning Solid Lubricants If a simple lubricant was present, friction coefficient was further reduced significantly. Fracture toughness of the epoxy was also improved. These lubricants may be used for rotating and sliding bearings. [13]

C. Porous Nano composites

The additions of nanoparticles can serve to improve the foaming properties of a polymer. Additions of silica nanoparticles to act as nucleation sites for Nano pore formation using carbon dioxide as a blowing agent.

D. Electrostatic Charge Dissipation in Space

Environment Dissipation of static charge on spacecraft is a severe problem, which requires a material with not only sufficient electrical conductivity but also must be stable to the space environment. Polymer precursor (e.g., poly (arylene ether)) with SWNTs in an ultrasonicator to disperse the SWNTs and then polymerized the organic polymer precursor using shear and elongational forces.

E. Ultraviolet Irradiation Resistance [9]

Common polymers are not stable under ultraviolet irradiation and will begin to degrade after few weeks. Strength and fracture toughness are drastically reduced and the polymer becomes brittle. The effect of modifying the epoxy matrix by adding nanoparticles of titanium dioxide to epoxy/carbon fiber composite. They found that resistance to degradation by ultraviolet irradiation could be reduced by approximately half and mechanical properties could be improved by 80 per cent. 3.9 Fire Retardation

F. 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. A silica-reinforced silicone Nano composite coating deposited to protect aluminum surfaces and electronic circuits. Corrosion protection in aerospace (at normal or low temperatures, not suitable above 150 °C) and corrosion protection of electronic circuits demand such materials.

G. Diffusion Barriers

Food packaging is dependent on preventing diffusion of gases and odours in airtight packets. Many tetra-packs. And similar liquid containers consist of several layers, including a layer of aluminum as an impervious barrier to prevent carbon dioxide or oxygen spoiling the contents.

H. Sensors

Electrical resistance of a semiconducting SWNT changed dramatically upon exposure to gas molecules such as NO2 or NH3. The existing electrical sensor materials including carbon black polymer composites operate at high temperatures for substantial sensitivity whereas the sensors based on SWNT exhibited a fast response and higher sensitivity at room temperature. [10]

IV. ACTUATORS

Nano composite-based actuators have reduced power requirements and linear motion directly. Dispersed a small amount (<5 vol per cent) CNTs in a polyurethane thermoplastic polymer (Morthane) and found that the resultant Nano composite could store (and release when required) 50 per cent more strain energy than the unreinforced polymer. The addition of CNTs allowed indirect (infrared) or direct (Joule heating) activation.

Fiber-reinforced Nano composite pipelines are emerging as a feasible alternative to steel pipelines with regard to performance and cost. In addition, the pipe can be manufactured with fiber optics, copper signal wires, power cables or capillary tubes installed directly into the structural wall of the piping. The application of reinforced Nano composites in oil and gas pipelines has the following advantages:

Nano composites used as a blend against plastics can be used for strengthening the portions of the automobiles where higher efficiency is required. Owing to their polymeric nature, polymer Nano composites fit this description. Because of their nanometer size features, polymeric Nano composites possess unique properties, such as enhanced mechanical, impact, barrier and heat resistant properties, compared to other composites.

Nano crystals of various metals have been shown to be 100 percent, 200 percent and even as much as 300 percent harder than the same materials in bulk form. Because wear resistance often is dictated by the hardness of a metal, parts made from Nano crystals will significantly last longer than conventional parts. [11]

Aircrafts Researchers have made relatively awesome discoveries on Nano composites over the last decade, ever since the pioneering work on Nano clay. The dispersion of the silicate Nano layer with its high aspect ratio, large surface area, and high stiffness within a polymer matrix results in significant improvement of the properties of polymeric materials, including mechanical properties, barrier properties, resistance to solvent swelling, ablation performance, thermal stability, fire retardancy, controlled release of drugs, anisotropic electrical conductivity, and photo activity.

Layered-silicate Nano composites have great applications, ranging from automotive and aerospace to food packaging and tissue engineering. These are also used in designing of aircraft parts too. This epoxy system has a high glass transition temperature (Tg), good mechanical and physical performance characteristics, and low viscosity. In addition, epoxy Nano composites as primer layer for aircraft coatings for improved anticorrosion properties are used. High performance Nano composites are also used in fuselage sinks in aircrafts.

A. Electronics

Conductive Nano composites are capable of conducting electric current well owing to the electric charges in their structure. Polycarbonates which is an insulator can be made conductive Polycarbonates, the inexpensive plastics known for their excellent optical and mechanical properties, could in future, find applications into newer and more important horizons.

Environmental Protection Water laden atmospheres have long been regarded as one of the most damaging environments, which polymeric materials can encounter. Thus an ability to minimize the extent to which water is absorbed can be a major advantage. Available data indicate that significant reduction of water absorption in a polymer could be achieved by Nano clay incorporation. Similar effects could also be achieved with polyamide-based Nano composites. Thus applications in which contact with water or moist environments is likely could clearly benefit from materials incorporating Nano clay particles.[12] Food Packaging The gaseous barrier property improvement that can result from incorporation of relatively small quantities of Nano clay materials has been shown to be substantial.
Excellent barrier characteristics have resulted in considerable interest in Nano clay composites in food packaging applications, both flexible and rigid. Specific examples include packaging for processed meats, cheese, confectionery, cereals and boil-in-the bag foods, also extrusion-coating applications in association with paperboard for fruit juice and dairy products, together with co-extrusion processes for the

Manufacture of beer and carbonated drinks bottles. The use of Nano composite packaging would be expected to enhance considerably the shelf life of many types of food.

B. Fuel Tanks

The ability of Nano clay incorporation to reduce solvent transmission through polymers such as polyamides has been demonstrated. The reduced fuel transmission characteristics are accompanied by significant material cost reductions. Nano composites are currently being used in a number of fields and new applications are being continuously developed. [14-17]
Other applications for Nano composites include:

- Thin-film capacitors for computer chips
- Solid polymer electrolyes for batteries.
- Automotive engine parts and fuel tanks
- Impellers and blades
- Oxygen and gas barriers [18]

V. CONCLUSION

Nano composites are suitable materials to meet the emerging demands arising from scientific and technologic advances. Processing methods for different types of Nano composites. The dispersion of the silicate Nano layer with its high aspect ratio, large surface area, and high stiffness within a polymer matrix results in significant improvement of the properties of polymeric materials, including mechanical properties, barrier properties, resistance to solvent swelling, ablation performance, thermal stability, fire retardancy, controlled release of drugs, anisotropic electrical conductivity, and photo activity. Thus all types of Nano composites provide opportunities and rewards creating new world wide interest in these new materials.

REFERENCE

[1] Ajayan, P; Schadler, L; and Braun,P. Nano composite science and technology Wiley VCH 2. Azonano, (2009) Nano composites.
[2] Ghosh NN, Pramanik P. 70. Aqueous sol–gel synthesis of nanosized ceramic composite powders with metal-formate precursors. Materials Science and Engineering: C 2001; 16(1-2):113-117.
[3] BBC Research Nano composites, Nanoparticles, Nanoclays, and Nanotubes. (2006)
[4] Buchholz, K. Nano composites Debuts on GM Vehicles Automotive Engineering International. (2003)

[5] Cammarata R. Introduction to Nano Scale Science and Technology Springer Publishers, USA. (2006)
[6] International Journal of Innovative Research in Science, Engineering and Technology 2014. Vol. 3, Issue 11,
[7] N Widiarti, J K Sae and S Wahyuni ,Synthesis CuO-ZnO Nano composite and its application as an antibacterial agent,IOP Conf. Series: Materials Science and Engineering 172 ,(2017)
[8] M. segovia,c. sotomayor,4 g. gonza´ lez,2,3and e. benavente mol Zinc Oxide Nanostructures by Solvothermal Synthesis. cryst. liq. cryst., 2012 vol. 555: pp. 40–50,
[9] R.V. Kurahatti*, A.O. Surendranathan, S. A. Kori*, Nirbha defense science journal, vol. 60, no. 5, september 2010, pp. 551-563, desidoc 551
[10] Kamigaito O. International Journal of Electronic and Electrical Engineering. ISSN 0974-2174, Volume 7, Number 6 (2014), pp. 603-
[11] Iijima S. Helical micro tubes of graphitic carbon. 6. Nature. 1991; 354(6348):56-58.
[12] Biercuk MJ, Llaguno MC, Radosvljevicm, HJ. Carbon nanotube 7. Composites for thermal management. Appied Physics Letters. 2002; 80(15):2767-2769.
[13] Ounaies Z, Park C, Wise KE, Siochi EJ, Harrison JS. 8. Electrical properties of single wall carbon nanotube reinforced polyimide composites. Composites Science and Technology. 2003; 63(11):1637 1646.
[14] Weisenberger MC, Grulke EA, Jacques D, Ramtell T, Andrews R. 9. Enhanced mechanical properties of polyacrylonitrile: multiwall carbon nanotube composite fibers. Journal of Nanoscience and Nanotechnology. 2003; 3(6):535-539.
[15] Ananthakumar S, Prabhakaran AK, Hareesh US, Manoharan P, 66. Warrier KGK. Gel casting process For Al2O3-SiC Nano composites and its creep characteristics. Materials Chemistry and Physics. 2004; 85(1):151-157.
[16] Sivakumar S, Sibu CP, Mukundan P, Pillai PK, Warrier KGK. 67. Nanoporous titania-alumina mixed oxides: an alkoxide free sol-gel synthesis. Materials Letters. 2004; 58(21):2664-2669.
[17] Warrier KGK, Anilkumar GM. 68. Densification of mullite-SiC Nano composite sol-gel precursors by pressureless sintering. Materials Chemistry and Physics. 2001; 67(1-3):263-266.
[18] Wunderlich W, Padmaja P, Warrier KGK. 69. TEM characterization of sol-gel-processed alumina–silica and alumina–titania nano-hybrid oxide catalysts.Journal of European Ceramic Society. 2004; 24(2):313 317.

