IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e- ISSN: 2278-1684,p-ISSN: 2320-334X
PP. 49-51
www.iosrjournals.org

A Review on Nanocomposites

[1]A. J. Bankar, [2]Mahmad Ziya Gous, [3]Nand Jee Kanu,
[1]*Assistant Professor, Mechanical Engineering Department, JSPM, NTC, Pune*
[2]*Assistant Professor, Mechanical Engineering Department, JSPM, NTC, Pune*
[3]*Research Scholar, S. V. National Institute of Technology, Surat*

Abstract: *In nanocomposite systems, catalytic activity is initiated particularly when Nano particles size are less than 5 nm, softening hard magnetic materials when particles size are less than 20 nm, producing refractive index changes when particles size are less than 50 nm, producing super paramagnetism and others electromagnetic phenomena when particles size are less than 100 nm and enhancing strengthening and toughening when particles size are less than 100 nm within same range.*
After discovery of carbon nanotubes (CNTs), a new and interesting feature has been added in to this area and thus initiating potential use to fabricate Nanocomposites having improved CNT based mechanical, electrical, and thermal features.
Nanocomposite materials can be classified in three different categories such as Ceramic Matrix Nanocomposites (CMNC), Metal Matrix Nanocomposites (MMNC) and Polymer Matrix Nanocomposites (PMNC) as per the matrix materials.
Keywords: *Nanocomposites, Carbon Nanotubes (CNTs), Nanotubes, Nanofibers, Resin Transfer Molding (RTM), Vacuum Assisted Resin Transfer Molding (VARTM), Electrospinning*

I. Overview

Nanocomposites are acting as high performance materials having remarkable property combinations and outstanding design possibilities. Their potential is so striking that they are useful in several areas ranging from packaging to biomedical applications with an estimated annual growth rate of fastest demand to be in engineering plastics and elastomers. As these are environmentally friendly, applications of nanocomposites thus offer new technology and business opportunities for potential sectors of the automotive, aerospace, electronics and biotechnology industries [1].

It has been reported in nanocomposite systems that catalytic activity is initiated particularly when particles size are less than 5 nm, softening hard magnetic materials when particles size are less than 20 nm, producing refractive index changes when particles size are less than 50 nm, producing super paramagnetism and others electromagnetic phenomena when particles size are less than 100 nm and enhancing strengthening and toughening when particles size are less than 100 nm within same range [2].

A new and interesting feature to this area has been added after discovery of carbon nanotubes (CNTs) in 1991 [3] and their further use to fabricate composites having some of the unique CNT related mechanical, electrical, and thermal properties added [4, 6]. Nanocomposite materials can be classified as per the matrix materials in three categories such as Ceramic Matrix Nanocomposites (CMNC), Metal Matrix Nanocomposites (MMNC) and Polymer Matrix Nanocomposites (PMNC) as given in Table 1 [1].

Table 1 Types of Nanocomposites (Pedro Henrique Cury Camargo et al., 2009 [1])

Class	Examples
Metal	*Fe-Cr/* AlO_3, *Ni/* Al_2O_3, *Co/Cr, Fe/MgO, Al/CNT, Mg/CNT*
Ceramic	Al_2O_3/SiO_2, SiO_2/Ni, Al_2O_3/TiO_2, Al_2O_3/SiC, Al_2O_3/CNT
Polymer	*Thermoplastic/thermoset polymer/layered silicates, polyester/*TiO_2*, polymer/CNT, polymer/layered double hydroxides*

Nanocomposite systems including CNTs reinforced nanocomposites have been focused since the 1990s and it has been observed that there has been a steady and continuous increase in the number of publications on this subject including reviews [7, 31].

Polymer composites are being manufactured for commercial applications such as sporting equipments, aerospace applications, automobile components, etc. Since, last 20 years, there has been a strong emphasis on the fabrication of polymeric nanocomposites, in which at least one of the dimensions of the filler material has to be in nanometer [32]. *And the most important thing is that the final product does not have to be in nanoscale, but could be micro- or macroscopic in size [33]*. By the advent of scanning tunneling microscopy and scanning probe microscopy in the early 1980s, this surge in the field of nanotechnology has been greatly facilitated. These powerful tools have facilitated scientists to discern visually the nature of the surface structure with atomic resolution [34] with computer technology to characterize and predict the properties at the nanoscale via modeling and simulation [33].

In a nutshell, the unique combination of the nanomaterial characteristics, such as size, low concentrations, and mechanical properties, actually these are necessary to effect change in a polymer matrix, coupled with the advanced characterization and simulation techniques which are now available these days, and due to that there have been wide interest in the field of nanocomposites [32]. In addition, many polymer nanocomposites can be fabricated and processed in ways similar to that of conventional polymer composites, making them particularly attractive from a manufacturing point of view.

In 1998, an article entitled 'Nano sandwiches', has been published by Chemistry in Britain stating, 'Nature is a master chemist with incredible talent' [35]. Polymers such as carbohydrates, proteins, and lipids have been used as natural reagents by nature to make strong composites such as bones, wood, and shells and those are further examples of nanocomposites, made by mixing two or more constituent phases such as particles, layers or fibers, where at least one of the phases is in the nanometer size range [32]. With the use of a combination of atomic scale characterization and detailed modeling nanoscale science and technology research is progressing [33].

In 1990s, Toyota Central Research Laboratories in Japan have reported work on a Nylon-6 nanocomposite [36], in which a little amount of Nano filler loading resulted in a significant improvement of thermal and mechanical properties. Kanartzidis quoted that the properties of nanocomposite materials rely on the properties of their individual parents (Nano filler and nylon, in this case), and also on their morphology and interfacial characteristics [35].

II. Conclusion

Challenges in Processing and Manufacturing of Nanocomposites

Nanocomposite materials hold true potential to redefine exactly the field of traditional composite materials both in terms of performance and advance potential applications. However, developing those processing–manufacturing technologies in terms of quantity and quality and value for commercialization will be one of the most important challenges.

Dispersion of nanoparticles or chemical compatibility with matrix materials is still amongst those important issues. The aim of improving those carbon nanofiber matrix interfacial adhesion issues and complete dispersion must be resolved prior to achieving the full potential of CNF nanocomposites.

References

[1]. Pedro Henrique Cury Camargo, Kestur Gundappa Satyanarayana, Fernando Wypych, 2009, "Nanocomposites: Synthesis, Structure, Properties and New Application Opportunities (Review Articles), Materials Research, Vol. 12, No. 1, 1-39.

[2]. Kamigaito O, 1991, "What can be improved by nanometer composites?" Journal of Japan Society of Powder Metallurgy, 38:315-321.

[3]. Iijima S, 1991, "Helical microtubes of graphitic carbon", Nature, 354(6348):56-58.

[4]. Biercuk MJ, Llaguno MC, Radosvljevicm, HJ, 2002, "Carbon nanotube composites for thermal management", Appied Physics Letters; 80(15):2767-2769.

[5]. Ounaies Z, Park C, Wise KE, Siochi EJ, Harrison JS, 2003, "Electrical properties of single wall carbon nanotube reinforced polyimide composites", Composites Science and Technology; 63(11):1637-1646.

[6]. Weisenberger MC, Grulke EA, Jacques D, Ramtell T, Andrews R, 2003, "Enhanced mechanical properties of polyacrylonitrile: multiwall carbon nanotube composite fibers", Journal of Nanoscience and Nanotechnology; 3(6):535-539.

[7]. Schmidt D, Shah D, Giannelis EP, 2002, "New advances in polymer/layered silicate nanocomposites", Current Opinion in Solid State & Materials Science; 6(3):205-212.

[8]. Wypych F, Seefeld N, Denicolo I, 1997, "Preparation of nanocomposites based on the encapsulation of conducting polymers into 2H-MoS_2 and 1T-TiS_2", Quimica Nova; 20(4):356-360.

[9]. Aruna ST, Rajam KS, 2003, "Synthesis, characterisation and properties of Ni/PSZ and Ni/YSZ nanocomposites", Scripta Materialia; 48(5):507-512.

[10]. Giannelis EP, 1996, "Polymer layered silicate nanocomposites", Advanced Materials; 8(1):29-35.

[11]. Wypych F, Adad LB. Grothe MC, 1998, "Synthesis and characterization of the nanocomposites K-0, K0, 1(PEO) xMoS2 (X = 0,5; 1,2)", Quimica Nova; 21(6):687-692.

[12]. Sternitzke M, 1997, "Review: structural ceramic nanocomposites", Journal of European Ceramic Society; 17(9):1061-1082.

[13]. Peigney A, Laurent CH, Flahaut E, Rousset A, 2000, "Carbon nanotubes in novel ceramic matrix nanocomposites", Ceramic International; 26(6):677-683.

[14]. Alexandre M, Dubois P, 2000, "Polymer-layered silicate nanocomposites: preparation, properties and uses of a new class of materials", Materials Science & Engineering; 28(1-2):1-63.

[15]. Gangopadhyay R, Amitabha D, 2000, "Conducting polymer nanocomposites: a brief overview", Chemistry of Materials; 12(7): 608-622.

[16]. Thostenson ET, Ren Z, Chou TW, 2001, "Advances in the science and technology of carbon nanotubes and their composites: a review", Composites Science & Technology; 61(13):1899-1912.

[17]. Pokropivnyi VV, 2002a, "Two-dimensional nanocomposites: photonic crystals and nanomembranes (review): Types and preparation", Powder Metallurgy and Metal Ceramics; 41(5-6):264-272.

[18]. Pokropivnyi VV, 2002b, "Two-dimensional nanocomposites: photonic crystals and nanomembranes (review). II: Properties and applications", Powder Metallurgy and Metal Ceramics; 41(7-8):369-381.

[19]. Gall K, Dunn ML, Liu Y, Finch D, Lake M, Munshi NA, 2002, "Shape memory polymer nanocomposites", Acta Materialia; 50(20):5115-5126.
[20]. Kickelbick G, 2003, "Concepts for the incorporation of inorganic building blocks into organic polymers on a nanoscale", Progress in Polymer Science; 28(1):83-114.
[21]. Fischer H, 2003, "Polymer nanocomposites: from fundamental research to specific applications", Materials Science and Engineering: C; 23(6-8):763-772.
[22]. Ray SS, Okamoto M, 2003, "Polymer - layered silicate nanocomposites: a review from preparation to processing", Progress in Polymer Science; 28(11):1539-1641.
[23]. Andrews R, Weisenberger MC, 2004, "Carbon nanotube polymer composites", Current Opinion in Solid State and Materials Science; 8(1):31-37.
[24]. Wang C, Guo ZX, Fu S, Wu W, Zhu D, 2004, "Polymers containing fullerene or carbon nanotube structures", Progress in Polymer Science; 29(11):1079-1141.
[25]. Pandey JK, Reddy KR, Kumar AP, Singh RP, 2005, "An overview on the degradability of polymer nanocomposites", Polymer Degradation and Stability; 88(2):234-250.
[26]. Thostenson ET, Li C, Chou TW, 2005, "Nanocomposites in context", Composites Science and Technology; 65(3-4):491-516.
[27]. Jordan J, Jacob KI, Tannenbaum R, Sharaf MA, Jasiuk I, 2005, "Experimental trends in polymer nanocomposites: a review", Materials Science and Engineering: A; 393(1-2):1-11.
[28]. Choi SM, Awaji H, 2005, "Nanocomposites: a new material design concept", Science and Technology of Advanced Materials; 6(1):2-10.
[29]. Xie XL, Mai YW, Zhou XP, 2005, "Dispersion and alignment of carbon nanotubes in polymer matrix: a review", Materials Science and Engineering: R; 49(4):89-112.
[30]. Ray SS, Bousmina M, 2005, "Biodegradable polymers and their layered silicate nanocomposites in greening the 21st century materials world", Progress in Materials Science; 50(8):962-1079.
[31]. Pandey JK, Kumar AP, Misra M, Mohanty AK, Drzal LT, Singh RP, 2005, "Recent advances in biodegradable nanocomposites", Journal of Nanoscience and Nanotechnology; 5(4):497-526.
[32]. Farzana Hussain, Mehdi Hojjati, Masami, Okamoto, Russell E. Gorga, 2006, "Review Article: Polymer-matrix Nanocomposites, Processing, Manufacturing, and Application: An Overview", Journal of Composite Materials, Vol. 40, No. 17, DOI: 10.1177/0021998306067321.
[33]. RTO Lecture Series, 2005, EN-AVT-129.
[34]. Nanoscience and Nanotechnologies, 2004 (Reproduced in part with permission 2005), The Royal Society & the Royal Academy of Engineering.
[35]. Oriakhi, C.O, 1998, "Nano Sandwiches", Chem. Br., 34: 59–62.