Review on Nano Materials and It's Aerospace Application

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ABSTRACT

Carbon nanotubes (CNTs) have received the foremost attention across the earth. These area units configurationally admire a two-dimensional graphene sheet rolled up into a hollow structure. With just one wall up the cylinder, the structure is termed a single-walled nanotube (SWCNT). The structure that appears sort of a concentric set of cylinders with a continuing layer separation of 0.34 A is termed a multi-walled nanotube (MWCNT). The Young's modulus is over 1 TPa and the tensile strength is about 200 GPa. The thermal conductivity can be as high as 3000 W/mK. With a perfect ratio, tiny tip radius of curvature and sensible emission properties, CNTs even have established to be wonderful candidates for emission. CNTs are chemicals functionalized, i.e. it's attainable to connect a range of atomic and molecular teams to the ends of sidewalls of the nanotubes.

1. INTRODUCTION

In 1950s, the need for composite materials with superior mechanical properties was a driving stimulus into carbon fiber research, which eventually led to progress in carbon whisker and single crystal graphite research. The emerging challenges of crack propagation and encountered fiber defects however called for alternative solutions for obtaining ultra-high modulus fibers [1]. One approach towards this goal was the employment of controlled synthesis of carbon fibers by utilizing a catalytic chemical vapor deposition (CVD) [2]. The progress in polymer based carbon fiber research was initially carried out on microscale filaments and consequently led to experimental identification of CNTs using transmission electron microscopy [1].

More detailed historical insight into carbon fibers and CNTs has been outlined by other researchers [3-7].

Polymer composite is a multi-phase material comprised of polymer matrix and reinforcing filler. Integration of the reinforcing filler results in composite material with synergistic mechanical properties that cannot be achieved from either component alone. As the mostly used composite material, fiber reinforced polymer composite material (FRP) has been employed in many industrial applications such as automobile, aerospace, and sports utilities due to their "Light and Strong" characteristics. In practice of FRP for high performance and structural applications, FRP layers are assembled together to make composite laminate to provide as needed engineering properties [8]. Epoxy is the most common polymer resin in composite laminate where it provides better design flexibility, enhanced mechanical performance, and good chemicaland electrical resistance. Nanocrystal materials are one of the most interesting branches of today's nanoscience and nanotechnology. Semiconductor nanocrystals exhibit unique size and shape-dependent optical properties due to the quantum confinement effects and thus may find a wide range of applications in optoelectronic devices, photo-catalysis, solar energy conversion and biological imaging. A prerequisite for successful attempts in this direction is the availability of nanoparticles of superior quality [9].

ISSN: 2321-8169
975 – 980

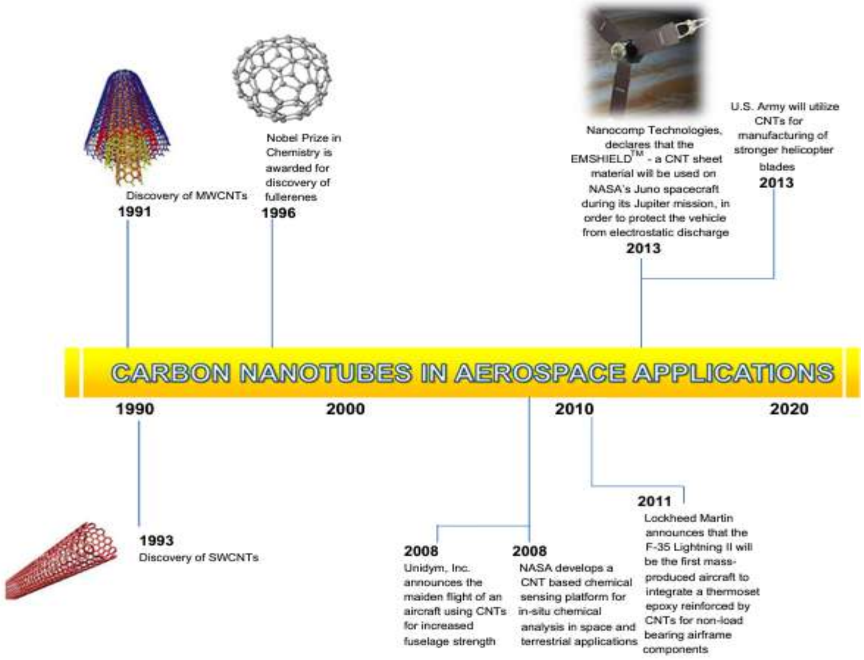


Fig-1:Carbon nanotubes in aerospace applications

and electrical resistance.Nanocrystal materials are one of the most interesting branches of today's nanoscience and nanotechnology. Semiconductor nanocrystals exhibit unique size and shape-dependent optical properties due to the quantum confinement effects and thus may find a wide range of applications in optoelectronic devices, photo-catalysis, solar energy conversion and biological imaging. A prerequisite for successful attempts in this direction is the availability of nanoparticles of superior quality [9].

2. LITERATURE SURVEY

Due to the numerous beneficial applications of CNTs in various scientific fields, the spectrum of the published literature regarding these materials has examined many of their characteristics in terms of atomic structure and morphology, processing, characterization, mechanics, and other chemical/physical properties in several books and review articles. In this section, a brief overview isprovided related to the characteristics of CNTs [1].

2.1.Classification

CNTs are commonly classified into two categories, termed single-walled carbon nanotubes (SWCNTs) and multi-walled carbon nanotubes (MWCNTs), with the former comprising a single sheet of graphite, rolled into a cylindrical tube. For MWCNTs, a perspective normal to the tube axis exhibits a family of concentric tubes. The conductivity of SWCNTs is based on the direction of the roll pertaining to the graphite sheet and the tube structure, determined by the two integers (n,m). Depending on the values of the integers m and n, the nanotube is considered to have a structure of:

Armchair:- n=m

Zigzag:- m=0

Chiral:- other n and m values than above

2.2. Manufacturing

Products featuring CNTs at the present have these implemented either dispersed in powder form or deposited as thin films. However, for commercialization of these products, it is crucial that such implementation is carried out in conjunction with existing manufacturing methods. It can be established that the optimal values attained for CNTs are yet to be realized. None the less, due to the wide research efforts conducted on these materials, advances in their manufacturing are constantly improving. Wang et al recently reported CNT composites with unprecedented multi-functionalities, including record high strength (3.8GPa), high Young's modulus (E) =293GPa, electrical-conductivity (s)= 1230Scm^{-1}, and thermal-conductivity (k) =41Wm^{-1} K^{-1}. These values were attained by employing along length, high volume fraction, good alignment, in conjunction with reduced waviness of the CNTs and a novel-processing approach feasible for a large-scale industrial production.

2.3. Experimental

a. BNNPs (Boron Nitride Nanoparticles)

2.3.1. Materials

Boron nitride nano-powder/nanoparticles (BNNPs) from U.S. Research Nanomaterials Inc. (Houston, TX) and washed with 2MNaOH at 80^{o}C before use. Fiber-Cote E-Glass Fabric 7781/E765 epoxy prepregs were purchased from Fibre-Glast Developments Corporation. Coupling agent 3-aminopropyl-triethoxysilane (KH550) and cetyl-trimethyl-ammonium-bromide (CTAB) were purchased from Sigma-Aldrich. All chemicals were used as received [8].

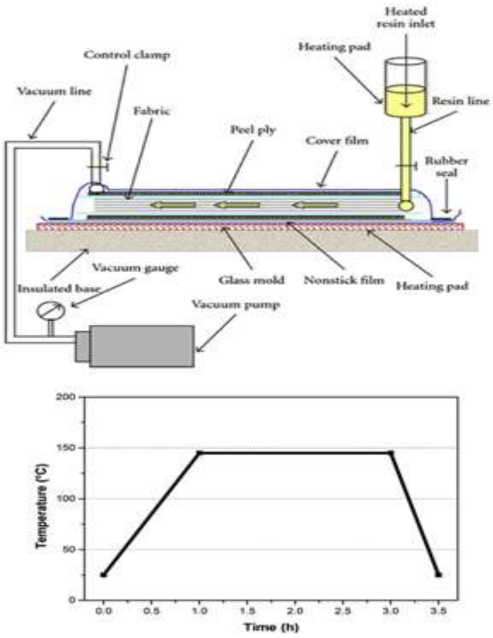
2.3.2. BNNPs functionalization

BNNPs chemical functionalization was carried out by one-step chemical treatment of pristine BNNPs with KH550 to get amino surface functionalized BNNPs (KH550-BNNPs). In a typical treatment, 6 g pristine BNNPs and 0.3 g KH550 were added into 200 mL ethanol solution (95%) followed by 30 min ultra-sonication. The resultant suspension was transferred to a flask equipped with a reflux condenser and maintained at 70^{o}C for 4 h under constant magnetic stirring. The reaction system was then centrifuged at 8000 rpm for 10 min. The obtained solid was washed three times with ethanol and subsequently dried in a vacuum oven at 60^{o}C for 24 h.

BNNPs physical functionalization was performed by adding 100 mL 1.5 mM CTAB aqueous solution to 10 g pristine BNNPs in a 250 mL flask. The flask containing BNNPs and CTAB system was first placed under ultra-sonication for 30 min, then transferred to a water bath at 80^{o}C and maintained there for 5 h followed by centrifugation at 8000 rpm for 10 min. The obtained solid was washed with DI water and dried in a vacuum oven at 60^{o}C for 24 h to get CTAB functionalized BNNPs (CTAB-BNNPs) [8].

2.3.3. Preparation of BNNPs enhancedprepreg and compositeLaminate

Fiberglass based composite laminates were prepared by laying up multi-layer of FiberCoteprepregs following a three-step procedure: brushing, lamination, and curing. BNNPs were dispersed in acetone first through ultra-sonication. Each prepreg layer was placed on a flat glass panel and brushed with the BNNPs acetone suspension evenly. These prepreg layers were left to dry at room temperature for half an hour. 12 plies of BNNPs enhanced prepregs were assembled one-on-one to laminate via hand lay-up. The laminate was vacuum-bagged and then cured at 143^{o}C for 3 has illustrated in Fig.1. Cured composite laminate was trimmed using diamond-grit wet cutting wheel and cut to specimens for mechanical test. Loading of BNNPs in final composite laminate was ~0.5 wt% [8].



Fig–2: Schematic diagram of vacuum bagging and curing cycle that are used for BNNPs enhanced epoxy composite laminates [8].

2.3.4. Characterization

Fourier-transform infrared (FT-IR) spectroscopy was recorded using a Varian 670 FTIR Spectrometer instrument over the range of 4000e400 cm_1. Scanning electron microscopy (SEM) images wereobtained using a Carl Zeiss Auriga SEM-FIB field emission scanning electron microscope. All SEM samples were sputter-coated with athin layer of gold to avoid charge accumulation. Thermogravimetric analyses were performed on a TA Instrument Q500 Thermogravimetric Analyser (TGA) at a heating rate of 10^{o}C/min under a nitrogen atmosphere. The crosshead displacement rate was set at 2 mm/min. five specimens were tested for each sample and the average was reported [8].

2.3.5. Application

Next generation aircraft, rotorcraft, unmanned aerial vehicles, and missiles will have stricter requirements in terms of light-weight, visual and thermal signature, increased speed, and manoeuvrability. These requirements, however, incite a need for advanced materials and systems that can incorporate these functionalities. CNTs are ideal candidates to meet these demands, as they can be incorporated in different technologies. In particular, this section examines weight reduction by replacement of current airframe materials and wiring which results in the reduction of fuel consumption. In addition, the potential benefits of CNT implementation for aircraft-icing, aircraft-lightning protection, propulsion systems, and safety aspects arediscussed. Wiring is the potential areas where a weight reduction and reduced fuel consumption can be obtained in aeronautics is the replacement of current copper wiring, which is significantly heavier than wires made of CNTs. A commercial airliner such as Boeing 747 has about 135 miles of copper wiring, which represents a weight of 4000lbs. According to scientists, a cable made of CNTs called 1553B can result in a 69% weight-saving. In addition such replacement would entail that premature failures and overheating caused by vibration fatigue, oxidization and corrosion of the copper wires can be avoided. Aircraft-Icing is with in aeronautics in which realization of CNT employment will be conducive is the field of aircraft-icing. This phenomenon develops upon existence of water droplets below freezing temperatures, or super-cooled droplets, in the atmosphere that impinge on the surfaces of an aircraft during flight. The nature of the icing that occurs is dependent upon the density of liquid water per unit cubic meter, or the liquid water content, droplet size, and temperature among other factors. The adverse effects of aircraft-icing on fixed-wing aircraft are reduction of lift and stall angle of attack, and an increase in profile drag. The more frequent usage of composite materials in aerospace applications offersnumerous cost-effective advantages such as increased fuel efficiency, reduction of acoustic emissions and pollutants.

Fig-3: The RHS technology employed by Battelle on a wing section exposed to icing conditions. The wing's right-hand side is ice-free following the usage of Battelle's anti-icing system [1].

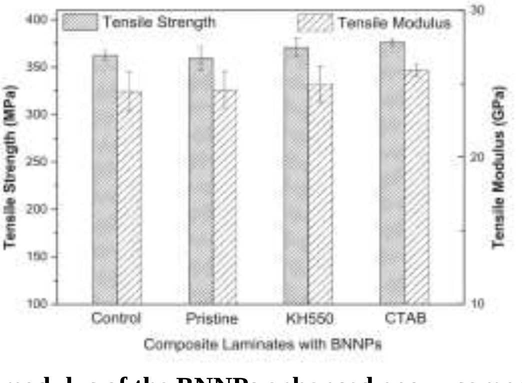


Fig-4: Tensile strength and modulus of the BNNPs enhanced epoxy composite laminates [8].

ISSN: 2321-8169
975 – 980

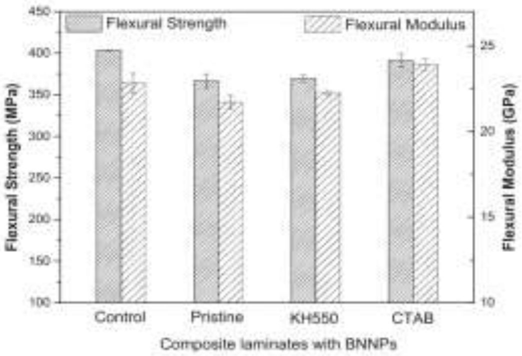


Fig-5: Flexural strength and modulus of BNNPs enhanced epoxy composite laminates [8].

a.Thermal conductivity:

In this study, we also investigated thermal conductivity of composite laminates with different types of BNNPs. Surprisingly, inclusion of pristine BNNPs decreased thermal conductivity of the laminate while functionalized BNNPs increased it by up to 2.04% (Fig. 5).Pristine BNNPs may form big agglomerates that would be detrimental to their dispersion in epoxy matrix. Furthermore there would be void space between BNNPs agglomerates and epoxy matrix due to the lack of interfacial interaction. Both factors could undermine the creation of thermal conductive networks.

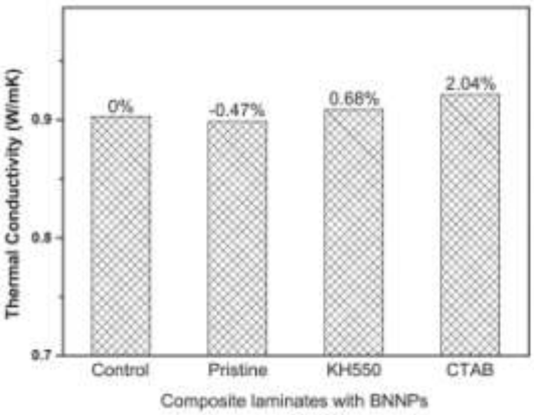


Fig-6:Thermal conductivity of BNNPs enhanced composite laminates [8].

b. CdSe (Cadmium Selenide)

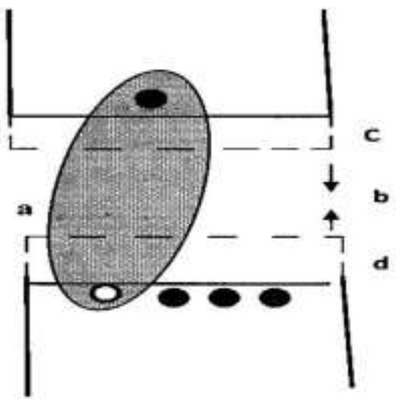


Fig-7: Illustration of the effect of quantum confinement on the formation of an exciton (coupled electron-hole pair); the symbols:- (a) Exciton; (b) Band gap; (c) Confinement energy of the excited electron; and (d) Confinement energy of the excited hole [9].

Production of CdSe:-

The CdO (Cadmium Oxide) was dissolved in stearic acid in a tri-neck flask at 180°C with stirring. The red color of CdO disappears and the solution becomes colorless. The Se powder was dissolved in TOP (Triostyl phosphine) and injected into Tri-neck flask at 210°C to 280°C. After injection we work on 11 samples from the reaction mixture for a time taken at a constant rate (15s). All samples were cooled with toluene to stop particle growth [9].

3.Conclusions

CNTs study has reviewed current and potential applications of CNTs for future commercial aircraft, military air- craft, UAVs, MAVs, space vehicles, satellites, aerostats, and the space elevator. Boron nitride nanoparticles (BNNPs) were surface functionalized and subsequently applied to surface of fiberglass prepress to fabricate hybrid BNNPs/fiberglass/epoxy composite laminate. To improve interfacial interaction between BNNPs and epoxy resin, two routes of BNNPs functionalization were carried out and compared: (a) chemical route with 3-amino-propyl-triethoxy-silane (KH550) treatment to introduce covalent bonding between BNNPs surface and epoxy matrix; (b) physical route with cetyl-trimethyl-ammonium bromide (CTAB) treatment to introduce better wetting between BNNPs and epoxy matrix. Experiments successfully have demonstrated the synthesis of CdSe nanocrystals by the hot injection method. Nanoparticles with varying sizes and band gaps emerge in the process and produced in spherical shape. The coloration of the nanoparticle is directly linked to the band gap. The color of the light depends on the size of the quantum dots. It is recognized that new concepts in nanotechnology will facilitate this implementation procedure despite current existing scientific challenges.

4.References

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