Review On The Application Of Boron Nitride Nanotubes

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Abstract. Boron nitride nanotubes (BNNTs) is a kind of material which have similar structure with carbon nanotubes (CNTs), but have more excellent performance, through experiments and research, scientists have a more thorough understanding of the preparation methods and properties of BNNTs, at the same time, they also explored the application value of BNNTs. This article summarized and introduced the application of BNNTs from the composite additives, hydrogen storage materials, biomedical materials and environmental purification material, and prospected the future development of BNNTs..

Introduction

Since the discovery of nanometer materials in the eighties of the 20th century, due to the excellent characteristics of good surface effect, volume effect, nanomaterial is widely used in the field of machinery, chemical industry, medicine and national defense. As a kind of special shape of nanomaterials, nanotubes has excellent physical and chemical properties, and boron nitride nanotubes (BNNTs) is one kind of it.

Until now, scientists has done a lot of research work for the preparation method of BNNTs, and also has made good achievements, the preparation methods of BNNTs which has been reported mainly include plasma arc discharge, laser ablation, chemical gas phase deposition method, ball-annealing method, template method and solvent thermal method. Although scientists has explored a variety of BNNTs preparation method, but it still is difficult to make a large amount of BNNTs in a single time, thus limited the research progress in other aspects, which need further research and exploration by scientists.

In terms of properties, the structure of BNNTs is similar to carbon nanotubes (CNTs), B atoms and N atoms staggered arrangement to replace the position of C atoms, and almost has no change in the atomic spacing. Due to the similarity in structure, BNNTs possess some similar performance with CNTs, but because the electronic structure of CNTs are different from BNNTs, BNNTs also show some unique properties which CNNTs doesn't have. BNNTs have good mechanical properties, thermal conductivity, thermal stability, electrical and optical magnetic properties and wetting properties. These excellent properties make BNNTs have potential application value in many fields.

Application of BNNTs

The additives of compound material. BNNTs have higher elastic modulus and tensile strength, high thermal conductivity rate, good chemical inertness and high temperature resistant properties. These properties make BNNTs become the ideal composite additives and can be used to improve the heat transfer performance of polymer and ceramic mechanical and thermal properties and improve fluid.

At present, Choi has prepared oxide glass enhanced by 4% BNNTs , material strength and toughness were increased by 90% and 35%, showed the outstanding mechanical properties of BNNTs. The study of Zhi found, the elastic modulus of polystyrene (PS) composite films which added about 1 wt% BNNTs increased by 21% while maintaining good transparency at the same time. In addition, compared to the pure PS, oxidation resistance of the composite was improved obviously. The research group of Chen[1] prepared a large number of BNNTs with boron ink, and

used it as an additive phase to enhance the poly amino acid (PU). Research shows that the 0.5vol% BNNTs made the compression modulus of matrix increased by 38.2%,. The hardness of BNNTs/PU composites decreased with the increase of the volume fraction of BNNTs. Duan[2] prepared the BNNTs/PVA (PVA) composites through green and simple method, BNNTs/PVA maintain good transparency, mechanical properties and thermal stability improved significantly. This makes the composite material with good resistance to high temperature, corrosion performance, suitable for working in the complex environment of flexible optoelectronic devices, visual window and radiating material preparation.

In the study of organic glass (PMMA), it was found that the oxidation resistance of the material was increased by adding 1 wt% BNNTs , while the elastic modulus increased by 19%. More importantly, the thermal conductivity of PMMA increased from 0.17W/mK to 0.5 W/mK with the addition of 10 wt% BNNTs, increased by nearly 3 times[3]. For the study of epoxy resin, it is found that the addition of BNNTs can effectively regulate the dielectric constant. The addition of 5 wt% of BNNTs can increase the thermal conductivity by 69%. The group also used Catechines on BNNTs for surface modification, prepared polyvinyl formal (PVF) and polyvinyl alcohol (PVA) composite materials. The thermal conductivity of PVF composites was increased by 160% with the addition of 1 wt% of BNNTs[4].

The research group Jianqiang Bi [5] enhanced ZrO2 ceramic and Al2O3 ceramic by adding BNNTs. Their study found that adding 1.0wt% BNNTs can make the flexural strength and fracture strength of ZrO2 Ceramic increased by 27.7% and 65.4%; add 1.5wt% BNNTs can make the flexural strength and fracture strength of Al2O3 ceramic increased by 58.9% and 17.3%. Recently, the results of this research group show that the addition of 1.5wt%BNNTs can make the fracture strength of Si3N4 ceramic increased by 40%[6].

Due to the nature of the BNNTs is light weight, insulation, high thermal conductivity, it can additives in preparation of nano-fluid , especially in dielectric nano-fluid preparation, and has broad application prospects. Recently, Zhi[7] prepared BNNTs/H2O nano-fluids with BNNTs as additives and test its thermal conductivity. The results showed that after adding 6vol% BNNTs, the thermal conductivity of the base fluid water rate increased by 2.6 times, while the thermal conductivity rate of the nano-fluid adding boron nitride nanometer ball (BNNSs) only increased 1.6 times.

Excellent hydrogen storage material. Hydrogen has attracted worldwide attention as a clean and renewable energy. However, in the process of utilization, safe storage and transportation has been the focus of research. The porous structure of carbon nanotubes and the characteristics of light weight, combined with a good combination of C atoms and H atoms, make it a promising energy storage material. The thermal stability and chemical stability of BNNTs are better than CNTs, and the properties of BNNTs are almost independent of diameter and chiral, which make it more promising to be a new hydrogen storage material.

The test results on the hydrogen storage properties of multi wall BNNTs show that, under the pressure of 10MPa at room temperature, the hydrogen storage capacity of multi wall BNNTs was between 1.8 and 2.6 wt%, The study of Tang et al. found that under the pressure of 10MPa at room temperature, the hydrogen storage capacity of the defective collapse like BNNTs can reach 4.2wt%, which is more suitable than CNTs as a hydrogen storage material.

The electrochemical hydrogen storage performance of BNNTs was tested and analyzed by Chen. Test results is disappointing, with discharge current density for 500 and 1000 g, discharge capacity is only 68 and 54 MAH / g, only equivalent to the hydrogen storage proportion of 0.25 wt%, far below the reaction of hydrogen storage capacity which was reported previously. However, the experimental results show that the hydrogen storage capacity of BNNTs is still much higher than the commercial sale of BN powder which is only 16 mAh/g under the same conditions. The author thinks that the main reason for the low hydrogen value of BNNTs is that the experiment is carried out under the normal pressure (0.1 MPa).

At present, The reported on the hydrogen storage of BNNTs is very limited, the research about mechanism of hydrogen storage isn't enough, different test results exist large differences, and theoretical study on the hydrogen storage also has large differences, and more theoretical and

experimental work needs to be completed.

Biomedical materials. Biomedical materials have always been the focus of research. BNNTs has the unique physical and chemical properties, and has potential applications in the medical field. BNNTs has good biocompatibility and can be used as a drug carrier. It also can promote the regeneration of bone cells, has great potential for development in plastic surgery.

The cell compatibility of BNNTs was first studied by Ciofani et al. [8]. Research results show that poly ethylene imine modified BNNTs does not produce great influence [9] on neuroblastoma survival, metabolism and cell regeneration. Their subsequent studies showed that the BNNTs modified by poly lysine had good cell compatibility with glioblastoma and fibroblast cells. At the same time, the modified BNNTs has become the carrier of transportation of B. Although the cell part of research is malignant tumors, but the related experiments show that BNNTs has good biocompatibility. Research results show that [10], BNNTs is a natural non-cytotoxic material, compared to the CNTs, which resulted in human embryonic kidney cells (HEK293) apoptosis, BNNTs didn't inhibit cell growth or production of apoptosis pathway. In addition, by noncovalent adsorption, surface modification of the BNNTs conjugates with biological activity, easy to engage with proteins and cells. Thus, BNNTs can promote the application in biosensors, biological and biological aspects of the imaging probe.

Italy researchers first suspended BNNTs in ethylene glycol chitosan solution (a bio foam solution), and then treated with ultrasound solution, so that these nanotubes broken into smaller units[11]. These solutions containing different concentrations of BNNTs were added to human epithelial cells then. The researchers followed up on the ability of BNNTs to kill cancer cells alone to observe and determine the concentration of BNNTs capable of killing about 25% cancer cells within 24 hours. Although the study is still in its early days, it may someday be a better way to treat cancer.

Not only the biological compatibility of BNNTs was studied, but also the related research on the biological composites containing BNNTs. Lahiri et al [12-13] researched the mechanical and biological properties of hydroxyapatite (HA) and poly exchange resin poly acid ester copolymer (PLC) which are reinforced by BNNTs. Compared with pure HA, the mechanical properties of HA composites containing 4 wt% BNNTs were greatly improved. The elastic modulus, hardness and fracture toughness were increased by 120%, 129% and 86%, and the wear resistance was improved by 75%, and the reinforcing and toughening effect was very obvious. Biocompatibility tests showed that the composite had no significant effect on the proliferation and viability of osteoblasts. The tensile strength of PLC composites with the addition of 5 wt% BNNTs increased by 109%, and the modulus increased by 1370%. Biological tests showed that the naked BNNTs had no cytotoxicity on osteoblasts and macrophages. Compared with the PLC matrix, the BNNTs/PLC composite could improve the survival ability of osteoblasts significantly. In a recent study in the subject group, BNNTs was able to induce the deposition of HA on the surface of the simulated body fluid, thereby promoting the application of BNNTs in plastic surgery.

Potential environmental cleaning materials. Scientists found that nanotubes edge showing floc characteristics, higher specific surface area of the BNNTs can be used as a good filtration、purification material. In the aspect of environmental protection, when BNNTs is used to filter out contaminants as filter material, due to its nano structure, BNNTs can play a very good filtering effect, at the same time, baking BNNTs after used, this material can be used repeatedly, these properties make BNNTs has great potentialities in environmental protection and pollution treatment.

Ruoxi Wang carried out the theoretical study of cobalt doped boron nitride nanotubes adsorption of chlorophenols. Chlorophenol (CPs) pollutants is the formation of dioxin pops precursor, has strong teratogenic, carcinogenic and mutagenic. As a new material to explore the removal these pollutants, using density functional theory (8,0) to research the adsorption behavior and mechanism of action of single wall boron nitride nanotubes (BNNT) and Co doped (8,0) single-walled boron nitride nanotube (Co-BNNT) to 2- (2-CP), 2,4,6- three chlorophenols (TCP), chlorophenols pentachlorophenol (PCP) . The results showed that compared with BNNT, Co-BNNT near the

Fermi level is a hybrid state, the band gap decreases. BNNT shows physical adsorption of 2-CP TCP and PCP, and Co-BNNT of three chlorophenolic is chemical adsorption, nanotubes and intermolecular charge transfer occurs, the system density of states near the Fermi level changed. Co doped significantly enhanced BNNT electron transport capacity, Improve the activity for the adsorption of nanotubes to chlorophenol. Co-BNNT is expected to be a potential resource of removal or detection of chlorophenols.

Summary

As a new type of nano materials, BNNTs has great potential for development. The exploration about BNNTs is still at the begining, the main factors that restricting its development is that the preparation method, although scientists have already explored a variety preparation method of BNNTs, but there isn't a preparation method which can get large quantity and high purity of BNNTs by a single time, the expensive price of BNNTs(about 16000 RMB / g) also limits the large-scale application of it. In addition, the problem of high cost and high energy consumption in the process of preparing BNNTs is also an important factor affecting the price. Because BNNTs has not realized the industrialization production yet, the large amount of pure BNNTs which is needed to complete other research work is difficult to obtain, this situation makes the research of BNNTs relatively slow.

Compared to the research of CNTs, research about BNNTs is still in its infancy. From the current research situation, BNNTs have shown excellent performance and great potential, with in-depth study, more performance of BNNTs will be explored, and improvement of preparation method also will promote this excellent material get more extensive application.

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