Boron-based Polymers for EV Storage

Boron-based polymers such as BNNTs are 2D nanomaterials with excellent properties for improving electric vehicle energy storage given their high surface areas.

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NEW YORK, USA, April 22, 2022 /EINPresswire.com/ -- Electric Vehicles Market is Growing
Electric vehicles have been on an upward trend for years, and predictions show that this will continue into the future. In 2020, the global market for electric vehicles was valued at USD 246.70 billion. Covid-19 has had a massive and unprecedented worldwide impact, with electric cars seeing a steady increase in demand in all regions.

According to the study, the global market growth was reported -9.7% in 2020, compared to average year-on-year growth from 2017 to 2019.

During the period 2021-2028, the market is expected to increase at a CAGR of 24.3 per cent, from USD 287.36 billion in 2021 to USD 1,318.22 billion in 2028. The abrupt increase in CAGR is due to this market's growth and demand, which is expected to revert to pre-pandemic levels once the coronavirus crisis hits.

Polymer Nanocomposites and BNNTs
How will boron nitride nanotubes support electrical power in vehicles? The answer may be through introducing BNNTs into polymer nanocomposites to improve electrical conduction.

Polymer nanocomposites incorporating BNNTs show enhanced dielectric properties due to the synergistic effects of the nanoparticles and the host matrix. However, the electrical conductivity of these composites is still too low to meet the requirements of practical applications.

To overcome this issue, researchers from Penn State University in Pennsylvania propose a novel approach based on the use of BNNTs having a wider bandgap than those of common semiconductors or insulators.

By introducing such BNNTs into the polymers, the electrical conduction of the composite can be effectively suppressed while maintaining the high dielectric property of the BNNTs. This strategy may open up a new avenue for designing advanced dielectric materials for energy storage.

Furthermore, it is evidenced that breakdown strength and mechanical moduli can be further improved by reducing the thickness of h-BN powders to boron nitride nanosheets (BNNTs) with a monolayer of a few layers.

BNNT Fabrication Process

In the BNNT fabrication process, Epitaxial growth of boron nitride nanosheets by chemical vapour deposition (CVI) is still challenging because the precursors must be separated into two parts. The precursor should be kept away from the substrate during the whole process. A proper substrate is also necessary.

For recently reported polymer dielectrics, the utilised BNNTs were mostly prepared via 'top down' methods, e. g. mechanical exfoliation, chemical exfoliation. These exfoliation methods ensure highly ordered crystalline phases of the products, but lateral sizes are usually limited to a few hundred nanometers. Unsurprisingly, it has been known for many years that strong lip–lip interactions exist between BN layers, making it difficult to achieve complete exfoliation.

The focus is then on developing high-yield mechanical or chemical exfoliation approaches for the scalable production of BNNTs. To date, exfoliation approaches yield not only small lateral sizes but also few layered crystallite structures, limiting the ability to produce large quantities of mono-layered BNNTs.

However, a recent study showed that a mild milling process could produce few-layered crystallites with slightly reduced lateral dimensions. This new approach may be useful for preparing large quantities of mono-layer BNNTs – a planetary mill is used for crushing h-BN into powder form.

Further, exfoliated BN sheets are produced using various methods such as ball milling, vortex fluid exfoliation, and hydrothermal exfoliation. These exfoliated sheets are then incorporated into polymer matrices. As a result, these composites show improved dielectric and thermal performance.

BNNTs Surface Functionalisation

To address mismatches in both physical and chemical characteristics between organic and inorganic phases, various surface modifications have been used to improve the interface compatibility between polymers and boron nitride nanotubes (BNNTTs). Morishita and Okamoto employed a facile exfoliation method to non-covalently functionalized BNNTTs with chlorosulfonic acids.

The functionalized BNNTTs improved the interfacial compatibility between the organic matrices and BNNTTs in the PMMA- and PBT-based nanocomposites. Huang and coworkers have functionalized the BNNTTs via two different methods –non-covalent functionalization by octadecyl amines (ODAs) and covalent modification by hyperbranched aromatic polyamides (HBPs).

It was found that the HBPs-modified BNNTTs show stronger interactions with epoxide resins in comparison with unmodified or ODAs-modified BNNTTs, resulting in increased multiple mechanical properties of epoxide/HBPs-modifBied BNNTT nanocomposites.

Late on, Wu et al have conducted a comparative study on dielectric properties of PVDF composites containing unmodified BNNTTs and three surface-modified BNNTTs with an average lateral size and thickness of 250 nm and 3 nm respectively via different methods.

The BNNTs-PVDF composite shows great potential in energy storage applications due to its unique combination of excellent dielectric properties, mechanical robustness and self-healing ability. The material can be used as an effective insulation layer for electronic devices or as a component in supercapacitors.

BNNTs in high-polarity polymer matrix

In an exciting development, nanocomposite films containing BNNTs exhibit higher permittivity than pure polymer films due to the high dielectric constant of BNNTs. In addition, the incorporation of BNNTs increases the electrical conductivity of the resulting nanocomposite films.

Boron nitride (BN) nanoparticles have in the past been used for a wide range of purposes, including lubrication, friction reduction, wear resistance, and thermal management. However, because dispersing these nanoparticles into polymer matrices is challenging, their use in polymer matrices has been limited to date.

According to a study, researchers have used an electrospinning technology to create a new polymer composite. When compared to a plain polymer matrix, the composite's Young's modulus was raised by three times. In both dry and wet situations, the coefficient of friction dropped by more than half.

The composite showed excellent thermal conductivity and mechanical properties. It has the potential to be used in a wide range of devices, including microelectronics, batteries, and other electronic components.

Current Limitations on Use of BNNTs

BNNTs have many desirable characteristics such as wide bandgap, high breakdown field, high dielectric constants and excellent mechanical properties. These characteristics make them ideal candidates for use in high-temperature applications.

Polymer composites containing BNNTs show great enhancements in dielectric properties and breakdown strengths. In order to achieve a high quality of BNNTs, the challenges as described above need to be solved. Barriers include liquid exfoliation technique costs which are still very high and production rate is low. The process is, unfortunately, toxic and harmful to humans.

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