Various Nanotechnology Applied in Practical Electric Vehicles

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Abstract. This paper is aiming to know the advanced nanotechnology applied the vehicles. This article collects a large number of data on nanotechnology. And nanotechnology is applied in vehicles by the development of society. Nanotechnology tends to give people much more convenience than before. The equipment made of nanomaterials has many advantages, lighter in weight, stronger in hardness, longer in life, lower in maintenance cost, and more convenient in design. During these advantages, the lighter weight and convenient design are the most important. In addition, nanotechnology not only can be used in materials and also can be used in high-technology industries like batteries, semiconductors, and communication satellite technology. At the same time, nanotechnology is widely used in electric vehicles. Electric vehicles are more and more popular than before. This paper analyzes this subject from three aspects, the application of nanotechnology in battery safety, nanotechnology for car components, and nanotechnology for car batteries. This paper shows the benefits of the cars use of nanotechnology on cars.

Keywords: Nanotechnology, battery safety, car components.

1. Introduction

Now, electrical vehicles are becoming more and more popular than before. Electricity has been used as a fuel for more than 100 years [1]. In the early days of driving cars, electricity was used. But later, with the increase in oil production and the decrease in fuel price, fuel cars began to become popular in the early 20th century, and electric cars gradually retired from the stage of history. But now, thanks to the rising price of oil, electric cars are back in vogue. With the development of technology, people spend much time investing the materials for electrical vehicles [2, 3]. Devices made of nanomaterials are lighter, harder, longer, cheaper to maintain, and more convenient to design. Nanomaterials can also be used to produce materials with specific properties or materials that do not exist in nature, biological materials, and biomimetic materials. During this process, nanotechnology is widely used in electrical vehicles, especially in batteries and car components. The investment is aimed to know the application of nanotechnology on electrical vehicles [4-6]. So, it gets many aims like the definition of nanotechnology, the reason nanotechnology is widely used, the applications of nanotechnology in electric vehicle manufacturing, and the applications of nanotechnology on batteries. Team members search some materials on the internet and read some books in the library to get basic knowledge. The paper gets some real-world examples and uses these data to compare with other brand products. It also uses measurement methods to measure some accurate data. Investors use these data to analyze and summarize. It also can use these data to give some advice and conclusion. The purpose is to know more about the principle of the application of nanotechnology and what kinds of materials use nanotechnology on electrical vehicles. This paper can show people how nanotechnology is useful in people's daily life. It gives other investors some guides to do further investments. This helps people to have deeper research on nanotechnology to make goods more efficient and lighter than before. And make people's life more convenient like transport and the military.

2. Nanotechnology on Battery Safety

2.1. Lithium-Ion Battery

Most electric vehicles are using lithium-ion batteries [7-10]. In a traffic accident, all the cars might catch fire or explode. Using lithium-ion batteries in electric vehicles will have a lower risk of fire explosion than in gasoline vehicles. The Lithium-ion battery is still combustible, which means that it still has a low risk to catch fire. If it is damaged, it can cause short-circuiting.

2.2. Nanotechnology on Lithium-Ion Battery

When the battery is overheated, it can rupture the battery and even combust. To prevent this to happen, it will accept the space inside of the battery, will increase the battery size and it will also increase the cost and complexity of the production process. Using Nanotechnology on the battery can solve this problem. It can reduce or eliminate the chance of a short circuit of the battery.

2.3. Materials

Nanostructured materials can greatly increase the surface area of electrolyte materials. Nanoparticles can increase the conductivity of ceramics and gels, when the conductivity of ceramics and gels are enhanced, they can replace liquid electrolytes [11]. Using nanoparticles and nanocomposite materials can improve electrolytes have been shown that it can improve the attributes of lithium batteries, and other technologies of batteries (Fig. 1).

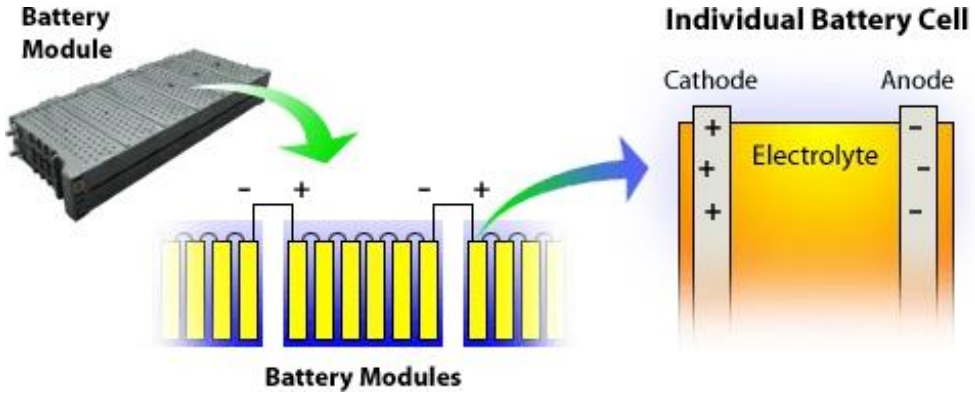


Fig. 1 A simple schematic of a battery [12]

2.4. How Can Nanotechnology Improve Battery?

Coating the surface of an electrode with nanoparticles can increase the available power from the battery and decrease the charging time that is required. Coating the surface of an electrode with nanoparticles allows more current to flow between the electrode and the chemicals inside the battery by increasing the surface area of the electrode thereby. It can also reduce the weight of the batteries needed to provide adequate power to increase the efficiency of hybrid vehicles. It can also increase the shelf life of the battery dramatically. It can do this by using nanomaterials to separate the liquids that are in the battery from the solid electrodes when the battery is not working. This can stop the low-level discharge that occurs in a conventional battery.

3. Nanotechnology for Car Components

Carbon fiber products are widespread in daily life. Such as fishing rods, phone cases, and car frames. Inspired by the common use of carbon fiber in daily life. Compared with carbon fiber, carbon nanotube has a substantial difference in character. Nanotube will have better performance than other materials in-vehicle components.

3.1. Carbon Nanotubes Introduction

Dr. Lijima, an electron microscopist at NEC, discovered carbon nanotubes in 1991 using a high-resolution electron microscope. This discovery added a new member to the group of carbon isomers that had previously been discovered. Ebbesen proposed a method for the synthesis of carbon nanotubes on a laboratory scale in 1992. This was a significant advance in the research that was being done on the properties of carbon nanotubes at the time.

Table 1. Mechanical performance of carbon nanotubes [13, 14]

	Steel	Carbon fiber	Carbon nanotube
Density	7.85 g/cm³	/	1.3 g/cm³
Young's modulus	200 GPa	600 GPa	1 TPa
Tensile strength	500 MPa	5.5-7 GPa	50-200 GPa

These data will explain the possibility and benefits of using carbon nanotubes instead of other materials. Carbon nanotubes have outstanding mechanical qualities due to their seamless cylindrical shape and a high degree of coordination of the tube body. Theoretically, a single layer of carbon nanotubes has a tensile strength that is 100 times that of steel, a mass that is only 1/6 that of steel, and an extension that can reach more than 20%. It is expected that carbon nanotubes can achieve quantum leaps in performance because they have outstanding strength, elasticity, fatigue resistance, and isotropy.

For instance, carbon fiber composite drive shafts for automobiles are lightweight, corrosion-resistant, and durable. In addition, they offer a high level of safety and excellent continuous vibration performance. Standard metallic drive shafts. The heaviness of a typical metal drive shaft makes it more vulnerable to damage, which can lead to excessive transmission noise. It also causes energy loss and shortens the service life of the drive shaft. Carbon nanotube composites meet structural component performance requirements. It is 70-80 percent lighter than a typical metal driveshaft and will extend the service life of the driveshaft [15].

3.2. Aesthetics

Electroplating, painting, and anodizing are some of the common methods that are utilized when it comes to the painting of car metal plates. Additionally, these varied painting method causes the vehicle to take on a variety of colors. There is a greater variety of colors available to the customer, giving them more options to select from according to their tastes. It is feasible for the automobile manufacturer to express its philosophy through the choice of a certain color, so improving both brand awareness and the dependability of its customers. However, carbon nanotube materials often cannot be colored, and carbon fiber products retain their original glossy black color. Imagine an entire car in pure black and the consumer has no choice but to give up performance for the appearance-conscious. But everything is changing. Recently, a study has proposed the first idea of using structural coloration to colorize carbon nanotubes: an oxide dense coating of only a few tens to hundreds of nanometers thick is applied to the surface of carbon nanotube fibers, which can refract, interfere, diffract and interact with visible light in a variety of optical ways. By adjusting the thickness of the TiO_2 coating, both carbon nanotube fibers exhibited controllable and brilliant colors.

3.3. Durability

The carbon fiber frame is simultaneously exposed to the sun, which hastens to age. Long durations of sun exposure, especially when used on frames, can raise the temperature inside the automobile beyond 70 degrees Celsius, which will drastically reduce the performance of the aging carbon fiber. The carbon nanotube exhibited remarkable super durability that could endure 2000 cycles of

laundering tests and more than 10 months of high-intensity ultraviolet irradiation (equivalent to the total sunlight of number of the sunny day 350 years) [16].

3.4. Safety

Two items are indistinguishable from one another in every way, except for their respective materials: one of the items is made of metal, and the other is made of carbon fiber. When the metal object fails, it will change shape in some way; it will either bend or break when it does so. Energy will be lost as a result of the deformation that will occur. When carbon fiber fails, it shatters into exceedingly small pieces that are unable to absorb any form of energy and therefore fail. The problem lies in the manner in which products made of a carbon fiber break. This is the more important issue. Carbon fiber can withstand facial impact pretty well, but it has extraordinarily little resistance to punctures. The only thing should be concerned about while dropping anything vertically is running the risk of striking a few sharp stones while doing so. By contrast, elasticity is also another astonishing characteristic of carbon nanotubes. The elasticity of nanotubes does have a limit, and under very physically powerful forces presses, it is possible to temporarily deform to the shape of a nanotube. This can happen when exposed to high force and press sitting and when exposed to great axial compressive forces. It can bend, twist, kink, and eventually buckle without damaging the nanotube. This is due to carbon nanotubes' unique one-dimensional tubular molecular structure, the perfect connection of hexagonal structures with far fewer defects than carbon fibers, and the different probabilities of sp^2 and sp^3 hybridization, which combine to make them an excellent fiber material with better properties than any other fiber is currently available.

3.5. Drawback

Unfortunately, this material is a composite despite having successfully entered the industrial market after transforming a laboratory synthesis 20 years ago, with a price of US$50-200 per gram, to a production of 100 tons, with a price of RMB 100,000 to several hundred thousand per ton. The need to use a large number of calculations and data in the process of work accumulation, while the entire production process, as well as the overall specification, in the vehicle shell and parts of any experience and case study. The only way to introduce carbon nanotubes to the U.S. automotive market is to achieve economies of scale and lower component costs [17].

4. Nanotechnology for Car Battery

4.1. Anode Nanomaterials

4.1.1 Molybdenum-based cathode materials for lithium-ion batteries

$LiCoO_2$ currently occupies a relatively important position in the market, but its capacity is not very high, and the price of Co is also more expensive, layered will have better capacity and structure, and thermal stability, but its manufacturing is very difficult, which makes it difficult for them to use large-capacity batteries, and in the process of deep de-lithium will be accompanied by the form of Li_2O to remove oxygen from the lattice, which will lead to changes in its internal structure. To optimize the above problems and solve them fundamentally, it is necessary to explore new strategies to build lithium-rich cathode materials with improved performance, of which energy density is the key to enhancing the battery, many researchers want to replace the Mn element in $LiMnO_3$ with other elements, which gives rise to Li_2MnO_3, a new lithium-rich material with a crystal structure of α-$NaFeO_2$ structure, which belongs to the R-3m space group with cell parameters of a = b= 2.8675 Å and c=14.8357 Å. It can carry Mo^{4+} to Mo^{6+} in the process of deuteration and embedding, so it has a high theoretical capacity.

4.1.2 Lithium-sulfur battery cathode material

Lithium-sulfur batteries are composed of a battery shell, a sulfur cathode, a lithium metal anode, an organic electrolyte, and a separator (diaphragm) group. The anode is generally a compound of

sulfur and carbon materials, and the electrolyte consists of lithium salt and organic solvent, whose main function is to allow only ions to pass, while electrons cannot pass, similar to the mechanism of a salt bridge. Since the active material sulfur in the current lithium-sulfur battery has poor electrical conductivity in the cathode material, to improve its electrical conductivity, researchers have proposed the use of carbon nanotubes as a material to improve the accumulated sulfur load, and the application of graded independent carbon nanotubes has achieved a sulfur loading of up to 6.3 mg/cm^2 per unit area.

4.1.3 CeO2/carbon-based and MXene-based lithium-sulfur battery cathode materials

In recent decades, continuous efforts have been made to overcome the defects of lithium-sulfur batteries by adding polar metal compounds to adsorb lithium polysulfide, inserting an electro-additive layer between the cathode and the diaphragm, etc. In recent years, two-dimensional excess metal carbides have attracted attention, namely for MXene, which is prepared by etching the A-layer in the MAX phase ($Mn^{+1}AXn$, n=1-4), and more than 30 kinds of MXene materials have been successfully synthesized, which can be directly used as high-magnification electrode materials to improve the electrochemical performance

4.2. Cathode Materials

4.2.1 Medium-temperature solid oxide fuel cell cathode material $Bi_{1-x}Ca_xFeO_{3-\delta}$

$BiFeO_3$ is a rhombic chalcogenide structure oxide with ferroelectricity, anti-ferromagnetism, and good oxygen transport properties, which are widely used in gas sensors, photocatalysis, and fuel cells. The larger ionic radii of Bi and Fe allow $BiFeO_3$ to accommodate more oxygen vacancies and facilitate oxygen ion transport, and Tu et al. reported oxygen ion conductivity up to 7.9×10^{-2} S/cm for $BFeO_3$ at 650 °C. However, $BiFeO_3$ is easy to be prepared in the process of The partial substitution of Bi by alkaline earth metals or lanthanides (e.g., S^{2+}, Ba^{2+}, Ca^{2+}, La^{3+}, etc.) can effectively suppress the generation of heterogeneous phases, and Tirupathi et al. used the combustion method to prepare $Bi_{0.8}Ca_{0.2}FeO_3$, the introduction of Ca^{2+} suppressed the formation of the second phase and improved the symmetry of the crystal structure. Also, Ca^{2+} doping is an effective material modification strategy. Wang et al. reported the effect of Ca doping on the material modification strategy. The effect of phase structure and conductivity of $NdFeO_3$ confirmed that the Ca ion introduction could improve the electronic and ionic conductivity of $NdFeO_3$; Gu et al. prepared Ca-doped $La_2NiO_{4+\delta}$, and the cell power was increased by 40% compared with $La_2NiO_{4+\delta}$.

4.2.2 Ce doped LaFeO3 fuel cell cathode material

Chalcogenide complex oxides with high electron-ion conductivity are widely used in SOFC cathode materials. Compared with Co-based chalcogenide air electrode materials, Fe-based materials with high ionic conductivity and high thermochemical stability and low cost have attracted extensive scholarly research. Feng et al. synthesized $LaFe_{1-x}Ce_xO_{3-\delta}$(x=0~0.2) series powders by citric acid-nitrate self-propagation combustion method. The DC four-terminal method was used to evaluate the conductivity of the materials, and the results showed that with the increase of doping, Cu elements can effectively increase the conductivity of the materials, and the maximum conductivity was 104 S/cm at x=0.2 at 700 °C. For chalcogenide oxides, the key to high ion-electron conductivity is to reduce the polarization resistance, so $LaFe0_3$-based chalcogenide oxide materials have more development prospects. $LaFe_{1-x}Ce_xO_{3-\delta}$ (x=0, 0.01, 0.05, 0.1) series cathode materials were prepared by the sol-gel method, and the doping by Ce elements did not change the crystal structure of $LaFeO_3$, but only caused the refinement of the grains, while the doping by Ce elements also led to an increase in the coefficient of thermal expansion of the material, which enhanced the match with the electrolyte (SDC). Conductivity and activation energy studies show that the conductivity increases with the doping of Ce elements and the conductivity is enhanced; electrochemical AC impedance studies show that the polarization impedance decreases significantly with the increase of the doping of Ce elements and the catalytic ability to oxygen is improved, which is expected to be a medium temperature SOFC cathode material.

5. Conclusion

In the first section, the paper shows the application of nanotechnology to battery safety, especially battery safety. It shows the Lithium-ion battery's materials and the way to improve the Lithium-ion battery. And the second part is to show the nanotechnology applications on vehicle components, it shows the benefits of nanotechnology on aesthetics, durability, and safety. The last section is aimed to know the car battery nanotechnology in different faces like CeO_2/carbon-based and MXene-based lithium-sulfur battery cathode materials, and their drawbacks. This also gave further research to nanotechnology and give people some good ideas to understand nanotechnology.

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