Application of Advanced Nanotechnology in Electric Vehicles

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Abstract. This paper focuses on nanotechnology and its relative applications in electric vehicles. The main parts of the article explain the role of electric vehicles in affecting the markets nowadays. The purpose is to give a direction for developing electric vehicles for future commercial use and suggestions for correcting some problems during the expansion of the electric vehicle markets. Applications of nanotechnology on cars have already developed and continued quickly. Nanotechnology helps a lot more for electric vehicles due to the advanced technology used, and there are still many problems faced by electric vehicles. The following part discusses the applications of nanotechnology on electric automobiles and the advantages of using the advanced method to improve the sales of electric cars. The applications are shown in various aspects, from car components inside car tires to the coating process of painting. The former two parts focus on the merits brought by nanotechnology. In the coating part, the theory of coating protection is discussed minutely. Another main part of the article is related to some challenges faced by the electric automobile industry nowadays, which require much more effort for manufacturers to fix the problem. Batteries and costs of cars make the electric car industry further succeed.

Keywords: Nanotechnology; electric vehicle; coating; energy; battery.

1. Introduction

The first electric car for practical use was released around 1890, which was even a much earlier year than releases the steam-powered and internal combustion engine. The capability of electric cars to reach a speed much higher than a horse -the original conventional transportation method at that time. People started purchasing electric cars, but few could afford the extremely high price. Since steam - powered cars were later released in the 1870s for mostly large institutions like trains and factories, the internal combustion engine was improved around the 1800s. Increased people changed to buying normal gasoline-powered cars. Electric cars at that time could only be suitable for women whose houses had enough electricity to charge the car and support the family. Since that, the path of electric cars has been hidden until nowadays. Because of the shortage of fossil fuels on earth and the increasingly serious global warming effect, cars powered by internal combustion engines are no longer the first choice of manufacturers and governments. Oil prices increase all around the world at the same time. New fuels with greater energy efficiency were on the way for exploration. Hydrogen-powered cars generate far less environmental pollution, and natural gas is also applied for transportation. China already put the mass production of taxis into society years ago. Electric vehicles have thus become a popular trend worldwide since people already have experiences in previous centuries.

Electric vehicles benefit from crossing into prosperous, blatant urban areas with less noise. It is greener progress for people living in cities. However, for people who want to drive for long distances, like taking a trip or traveling to another country, electric vehicles cannot reach the goal since the short endurance mileage of the batteries and their heavy loads. Therefore, although electric vehicles have prominent advantages, some problems are urgent to be fixed. Batteries are now becoming one of the most serious questions in electric cars for not giving efficient enough energy to power the car compared to the internal combustion engine and the additional weight on the chassis. Besides, the cost of building an electric car is still high. It seems like there are miles the distance to succeed in the electric vehicle industry.

2. Unique merits for applying nanotechnology

Nanotechnology first emerged in 1959 by a physicist called Richard Feynman, which pointed out that atoms and molecules can be controlled and manipulated by people intentionally. Since every object on earth is made of atoms and molecules, people can change the properties of the object by changing the structure of atoms at the micro level. High-performance materials are gradually coming up as technology keeps developing. The naked eye cannot observe nanoparticles since one nanometer equals the size of ten to the power of negative nine meters. The advanced research and equipment make this field far more important than others. It can be applied to many different areas and combined with other subjects to help solve the problems humans have been unable to solve for centuries. From household products to aerospace components, the existence of nanotechnology covers almost all areas in which humans are involved. The various enhanced materials greatly help to improve the living standard globally. Food, institutions, hygiene, environment, and others are related to residents' daily lives worldwide. Using nanotechnology to help save the electric cars industry is undoubtedly the most valuable thing for improving the world. Not only on the materials on bodies of cars but also the correction and progress on batteries make the industry increasingly successful and develop at a striking rate of speed. Some applications of nanotechnology on electric cars will be explained in detail in the following part.

2.1. Light weight and high strength

With the help of nanotechnology, two different types of materials can be combined into nanocomposites. Making nanocomposite materials involves inserting one material into another, including the nanoparticles inside the structure. The stepped-up materials usually have higher strength with lower densities than the original two types of materials [1]. The accurately designed composite material combines prominent properties of both materials and produces advantages that never appear on any conventional material. Combining two materials allows people to adjust the final product's properties for specific use in a certain area. For example, the metal alloys used in mechanics engineering need to be stronger than the original one to support the heavy loads' weight. For electric use, the nanocomposites need higher endurance than the normal materials and, far more importantly, the conductivity of electricity when placed into electric circuits or connected to batteries [2].

In most cases for nanocomposites, this paper will discuss one of the composites: polymer nanocomposites. Materials are incorporated and manipulated in polymer structures inside the atoms. The preliminary experiment combining materials in polymer structure fields successfully produced fullerenes [3]. Moreover, further, development generates carbon nanotube, which is frequently used in multiple fields according to its various properties. Carbon-fiber materials produced by polymer nanocomposites, which contain similar properties to carbon nanotubes, are particularly applied to car frames, bodies, and chassis. The surrounding materials are covered with carbon nanotubes for the engine part because of the thermal stability and gas permeability [4]. The combustion chamber works perfectly with the flowing air passing through, and components will not be affected by extremely high temperatures for a long period. The vehicles' framework includes many carbon nanotubes to enhance the tensile strength and prevent deformation when accidents happen. The special memory effect of reshaping after the deformation by forces even makes the cars repair themselves for trivial scratches and make the car's color more transparent and cleaner, which will be discussed in detail in the following. The nanotubes in the interiors of vehicles give the passengers strong safety and comfort since the modified grain size of the carbon-mixed materials will fill the bumpy surface of the original materials. For those manufacturers who make supercars themselves without any production line, carbon fiber will be largely used to reduce the car's weight and increase the strength of the whole body structure, like the new conceptual car made by Apollo in Figure 1. Those high-density materials decline the volume of the space placed and the mass of the materials.

Figure 1. Apollo ie made of painted carbon fiber for the whole car frame [5].

Furthermore, nanocomposites can be used in batteries as the electricity's superconductivity. The panels that carry the battery groups at the bottom of the vehicle will add nanotubes that can carry the electric current when the energy is released to power the cars [1]. It has the function of recycling the energy when the car is breaking. The energy will be restored by absorbing the car's kinetic energy while driving and flowing back to the batteries to recharge. Therefore, the energy batteries released for one time can be reused most of the time as cars often need braking and accelerating tautologically. The batteries' life cycle will be largely increased, and the efficiency will also be elevated.

2.2. Driving further distance and fewer accidents

As one of the earliest types of applications of nanotechnology, tires, the most crucial component of vehicles, has a remote history of using nanomaterials. A top level of the quality of tires affects the performance of automobiles. Grip and traction provided by designing different grains determine the daily purpose of driving a certain car and its stability when doing hard brakes or sharp turns [6]. Sizes and materials of a tire may even help to decide the fuel range of a car. Various materials have special properties, leading to the consumption rate of tires driving miles of range on the road. Some large SUVs or limousines have horrendous fuel consumption rates not only because of the heavy weight of the cars and large engines but also more significant sizes and materials of tires. Different choices of wheel hubs also contribute to the efficiency of driving power. Recently, however, nanotechnology has made a breakthrough in all these aspects.

Using a method similar to polymer nanocomposites, multiple raw materials are mixed to make tires for different functions, from domestic and off-road to professional races. Properties of rubber are improved by combining with soot, silica, and carbon black to form a reinforced filler to prevent collisions when the tire is hitting something hard and sharp, like rocks or spikes. The final product is equipped with high endurance and tight grip on roads. Moreover, adding nanotubes to electric cars can conduct electricity or gain energy from the friction of tires and roads (Figure 2). According to research, the energy from contact with the pavement will save 10 percent of the fuel used to consume the friction [7]. The reshaping memory function of tubes may even help cars to fix the tires immediately when air leakage occurs.

Figure 2. Lamborghini's full electric concept car with nanotube tires [8].

3. Application on coating

The vehicles' outlook is vital for producers and consumers to get a comfortable visual experience. The coating is used to add on the paint to protect the body of cars and make cars more beautiful. Nano-ceramic coating is applied to place an additional layer on the external surface to perfect the paintings.

Theories of nano-coating on car frames can be easily understood. Vehicles have to be cleaned up with soap and water. The alkaline elements reacted to the dust and other dirty impurities and left a completely clean surface of the paintwork without any other materials. Nanoparticles are painted by spray or a thin film put up by workers manually because they can filtrate into molecular structures or inside the atom of another material. Different from the previous parts of nanocomposites, instead of changing the internal structure, nanoparticles will get into a deeper level of the surface to fill all the gaps between the original paintwork. A transparent protection layer will appear on top of the car frames with higher resistance to corrosion and longer endurance to make the colors of the vehicles bright all the time. The sealed barrier prevents other harmful particles from entering and reacting with the frames [9]. The smooth surface gives a quick repairing ability of scratches and reflection of ultraviolet rays instead of absorbing them and getting harmed. Some scientists invented a coating containing nanotubes to monitor the situation of the coating [10]. Smart coatings contain a bunch of advantages for the protection of the bodies of vehicles. Coatings can react with some of the chemicals on the original color painting of the cars or with carbon emissions to neutralize the matter. Nanocoating is mixed with particular chemical properties used for certain applications [11, 12]. For instance, the UV-curable coatings, which contain the micro level of fillers inside the structures with even distribution of nanoparticles like silicon dioxide, can resist scratching on the surface of vehicles. Besides, the smoother surface and excellent resistance in other chemicals to prevent erosion appear in the markets [13].

With the developing technology in communication, the coating will become a protection for cars when accidents happen and a monitoring tool for the whole car. It can be a computer checking all the details of the cars from the reaction of coatings on different parts. For example, the information about high temperature in the combustion chamber will be transferred to drivers since the heat will conduct on the hood with a smart coating to detect unusual temperature levels. It will alert the driver to fix the problem immediately [12]. Besides, it helps drivers on daily trips. The coating will detect the temperature outside the car and report the information to passengers inside the car. People do not have to step out of the car and check whether it is rainy or snowy outside, which helps them ensure the preparation work is completed and thus avoids unnecessary problems.

4. Challenges of THE ev industry

Electrification of automobiles brings many benefits to increasing the living standard of citizens and higher manufacturers' profits. However, advanced technology is still insufficient to enlarge the electric vehicle market for many reasons, from the industry to the position and relationship it connects to the world.

4.1. Batteries

Batteries have one prominent shortage compared to gasoline: lower power output efficiency. Electric cars now have the problem of utilizing electricity incompletely to convert it into power to drive on the road. They have the problem that due to the low energy density and specific energy values compared to fossil fuels, it requires a large group of batteries like panels made up of small battery cells to power the cars but only for a short distance [14]. The battery's capacity is limited, and the heavy mass of the battery cells construct the problem of too much weight in the final product. The heavy mass will only lead to the losing power output of batteries because they have to consume more energy on accelerating. The longer charge and recharge time, up to 2 to 3 hours, also reduces the efficiency.

Moreover, electric cars will be similar to our cell phones; the charging rate becomes more frequent since the increasing use time on batteries cause them to forget the original capacity, what is more, the endurance of the batteries. For now, most electric cars can only drive in towns or cities for short ranges; none of the cars will reach the mile range maximum value beyond 700 kilometers. The choice of driving an electric car is not affluent worldwide.

4.2. Economics

The commercial disadvantages must be considered for expanding the electric automobile market. A lot of the money needed to be invested in constructing charging facilities like supercharging stations [14]. These infrastructures need to spread worldwide, from the countryside to metropolitans. Moreover, the costs of building an electric car are still amazingly high. With the addition of nanotechnology and new materials, producers must increase sales prices to earn profits. Factories need to build for mass production, and production lines need workers. Places, labor, and natural resources are crucial to the electric industry's success. It is challenging for the government to think about plans to invest such a huge amount of money.

5. Conclusion

In conclusion, with the help of nanotechnology, the electric automobile industry is progressing and improving more quickly. Crucial troubles like the heavy loads of the battery panels and the safety issues have already been fixed. Nanoparticles are added to the internal structure of the materials to improve their conditions. Not only to increase the strength and lower the density to make the materials lighter and stronger to respond to the various road conditions and make the vehicles able to provide higher output power. Nanotubes' applications on coatings take a big leap into the new era of the microscopic field. Apart from enhancing the chemical properties of elements and perfecting the performance of the original color painting on vehicles, nanotubes can also monitor the conditions of all the parts on frames to check if any of the components are malfunctioning. The combination of nanotechnology with electric vehicles largely pushes electrification to a higher status with a faster rate of development. Challenges are still waiting to be dealt with, and other serious problems require more sources. The electrification of all the components in vehicles causes the requirements of working under a relatively ideal environment in any conditions. It is hard to keep safe and stable to make battery units work for a long time compared to conventional fossil fuels. Furthermore, electrifying vehicles for commercial use creates a big problem of the higher costs of massive production. New factories needed to be established with nanotechnology, which is still an expensive technology used by a few industries. There is still a long path for electric vehicles in the future.

References

[1] Soutter Will, "Nanotechnology in Electric Vehicles Batteries." AZO Network, 15 Jan 2013, https://www.azonano.com/article.aspx?ArticleID=3157#:~:text=Nanotechnology%20could%20hold%20the%20key%20to%20making%20electric,as%20well%20as%20other%2C%20more%20novel%20battery%20technologies.

[2] Jaster Matthew, "Nanotechnology in Electric Vehicles." Gear Technology, 19 May 2022, https://www.geartechnology.com/articles/29898-nanotechnology-in-electric-vehicles

[3] "Berger Michael, "Nanotechnology in the automotive industry." Nano werk, 12 Nov 2010, https://www.nanowerk.com/spotlight/spotid=18972.php#:~:text=Nanotechnology%20in%20Tires%20Tires%20are%20one%20of%20the,in%20tires%20as%20a%20pigment%20and%20reinforcing%20agent

[4] Berger, Michael. "What Are Nanocomposites?" Nanotechnology, 18 Aug. 2021, https://www.nanowerk.com/nanocomposites.php#:~:text=Polymer%20Nanocomposites%20in%20the%20Automotive%20Industry%20The%20key,performance%20%28greater%20safety%2C%20increased%20comfort%20and%20better%20driveability%29.

[5] "Apollo Showcases Lightweight Hypercar Made of Carbon Fiber at CIIE." CGTN, https://news.cgtn.com/news/2020-11-06/Apollo-showcases-lightweight-hypercar-made-of-carbon-fiber-at-CIIE-VcM3n8mCwU/index.html.

[6] Hilton Simon, "How Nanotechnology is Revolutionising Tyres." AG Chemi Group Blog, 7 July 2020, https://blog.agchemigroup.eu/how-nanotechnology-is-revolutionising-tyres/

[7] Johnson Dexter, "Nanogenerator Produces Energy from Tires Rolling on Pavement." IEEE Spectrum, 30 Jun 2015, https://spectrum.ieee.org/nanogenerator-produces-energy-from-tires-rolling-on-pavement

[8] “Warping to the Future – Lamborghini Terzo Millennio!” HD Wallpapers & Backgrounds, 4 May 2018, https://freeaddon.com/lamborghini-terzo-millennio-preview/.

[9] "What Is Nano Technology & How Does It Work in Car Care Products?" Auto Detailing Supplies | Car Cleaning Products | Reviews Tips & Tricks, 20 Feb. 2021, https://www.performancemotorcare.com/what-is-nano-technology-and-how-does-it-work-in-car-care- products/.

[10] "What Is Nano Car Paint Protection and How It Works?" Nasiol, 15 Sep 2020, https://www.nasiol.com/nanoblog/what-is-nano-car-paint-protection/.

[11] Desk Auto HT, "What is nano ceramic coating and does your car need it? Here's a complete guide." HT Auto, 16 Mar, 2022, https://auto.hindustantimes.com/auto/news/what-is-nano-ceramic-coating-and-does-your-car-need-it-here-s-a-complete-guide-41647405225353.html#:~:text=To%20put%20simply%2C%20nano%20coating%20is%20the%20application,surface%20of%20a%20vehicle%20resistant%20to%20minor%20scratches.

[12] Gosselin, Cynthia A. "Nanotechnology in the World of Paints and Coatings." American Coatings Association, 12 Jan. 2022, https://www.paint.org/coatingstech-magazine/articles/nanotechnology-in-the-world-of-paints-and-coatings/.

[13] "Top 15 Best Ceramic Coating for Cars - Ultimate Guide 2022." Car Care Ninja Team, https://www.carcareninja.com/best-ceramic-coating-for-cars/

[14] Lozanova, Sarah (Feinstein). "6 Issues Facing Electric Vehicles." Earth911, 26 Nov. 2021, https://earth911.com/eco-tech/6-issues-with-electric-vehicles/#:~:text=6%20Issues%20Facing%20Electric%20Vehicles%201%20Electric%20Vehicle,to%20find%20a%20qualified%20mechanic%20in%20your%20area.