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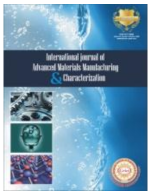

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Avant-garde Nanotechnology applications in Automotive Industry

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ABSTRACT

Need of mobility all across the world is increasing exponentially. Automobile industry has continuously played a crucial role in the progress of society. The demand of automobiles is increasing rapidly all over the world. The rising economies of various countries will further increase the demand of automobiles. In order to achieve safety, comfort, fuel efficiency while being environment friendly automobile companies are investing heavily in research and development. In this context, nanotechnology is likely to play an important role. Nanotechnology is opening new doors for innovative products and applications in automobile sector. This paper focuses on the advantages of using nano-sized materials in automobiles to increase their durability and efficiency. It briefly explains diverse venues of application of this new technology in the automotive sector.

Introduction

Nanotechnology deals with manipulation of matter at near atomic level to produce new structures, materials, systems and devices that exhibit properties that are unique at these scales. It also involves the production and application of physical, chemical, and biological systems at atomic or molecular scale to submicron dimensions and also the integration of the resulting nanostructures into larger systems. Therefore, nanotechnology deals with the large set of materials and products which rely on a change in their physical properties as their sizes are so small. The potential benefits of miniaturization and the unique properties of nanoparticles open the possibilities of innovation in various diverse fields from health to security and from auto motives to airplanes.

Advantages of nano dimensional materials

Mechanical properties:

In nanostructured materials there is significant increase in mechanical properties like higher hardness, increased breaking strength at low temperature. This behavior is attributed to the decrease in grain size when nano-materials are used, which is below the dimension where the deformation does not occur in the grain itself [1]. Hence, traditional polymers can be reinforced by nanoparticles leading to novel materials to be used as lightweight replacements for metals. Such enhanced materials will enable a weight reduction together with an increase in durability and enhanced functionality [2].

Geometric properties:

At nanometer scales, the surface properties start becoming more dominant than the bulk material properties, generating unique material attributes and chemical reactions[3]. Interactions in different media therefore require special physical and chemical properties of the surface of the particles, fibers, pores and the products. With regard to protection function, these demands include resistance against oxidation, corrosion, mechanical abrasions and high temperature [1]. By increasing the surface area the number of surface atoms increases dramatically, making surface phenomena play a vital role in materials performance influencing the chemical activity if the materials. This is because a greater amount of a substance comes in contact with surrounding material [2].

Optical properties:

Fundamentally, the electronic structure of materials becomes size-dependent as the dimensions enter the nanoscale. Delocalized electronic states as in a metal or a semiconductor are altered by the finite dimensions. Hence, the optical properties, including light absorption and emission behavior, will be altered [3]. The size of the nanoparticles is comparatively smaller than

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the wavelength of visible photons also impacts the than the wavelength of visible photons also impacts light scattering, enabling the design of nanocrystalline ceramics that are as transparent as glass [3].

Nanotechnology in the automotive industry

The automotive industry is an important global driver of growth, income, employment and innovation. Nanotechnology contributes significantly to necessary developments and to the production of innovative materials and processes in automotive sector. The crucial advantages generated by the application of nanotechnology in the automobile sector are: lighter but stronger materials (for better fuel consumption and increased safety); improved engine efficiency and fuel consumption for gasoline-powered cars (catalysts; fuel additives; lubricants); reduced environmental impact from hydrogen and fuel cell-powered cars; improved and miniaturized electronic systems and better economy (longer service life; lower component failure rate; smart materials for self-repair). Nanotechnology if incorporated in the manufacture of automotive components can result in enhanced efficiency levels in different aspects of the automobile [2].

Nanotechnology for an improved chassis

The safety of the car and the passengers is one the major objective of development of nanostructured materials and structures. Apart from this more flexible, light weight yet high strength nanostructures can be used to increase the performance ultimately reducing the fuel consumption and hence the economy of the operation[1].

High strength steels for car bodies:

Steel is one of the most important materials in the construction of the body of the automotive. Several companies have attempted using high strength steels in car bodies. However recasting the high strength steels in cold state is a difficult task as the size accuracy changes and undesirable spring-back effects may occur. Recasting in a hot state (at 1000 °C) helps us to avoid such disadvantages during recasting of high-strength steel parts. However, the scaling of this kind of steel is difficult at high temperatures. Nanotechnology can be used to solve this situation; a multifunctional protective coating can be produced based on nanotechnological approach with the principles of conventional paint technologies. This multifunctional coating is produced using bonded and connected nano sized vitreous and plastic like materials together with aluminum particles [2].

Nanotechnology for the shell of the car:

Nanotechnology offers an effective solution for scratch resistant, dirt repellent and self-healing car paints. Nano coatings consist of very small particles which facilitates flexibility, quick adhesion and resistance to corrosion and microbial growth.

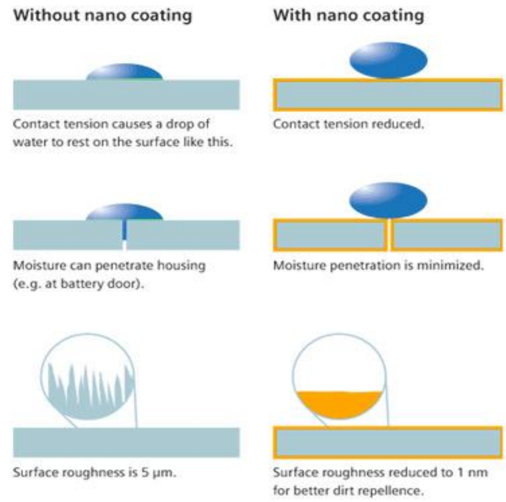

Figure: 1 Advantages of Nano coating.

As shown in the figure nano coats have the following advantages in cars:

1. The better grip of the substrate on the surface does allow another substance to penetrate the surface.
2. Since the size of the nano particles is less than 100 nm it fills glossy sized pits in glossy surfaces and improves the gloss.
3. Nano-particle UV inhibitors are perfectly clear yet they absorb UV light energy.

Another major problem faced by automobiles is driving during heavy rains can be very dangerous due the poor visibility due to the raindrops on the windshield and water sprayed by wheels of other vehicles. This issue has been addressed by the invention of permanent hydrophobic nano-coating for glass surfaces by German scientists. This is illustrated in figure 2.

Figure 2: The difference with and without hydrophobic nano coating.

Nano-coatings with anti-corrosion properties

Conversion Coatings are used to prevent corrosion and protect metal body against corrosive materials. Conversion coatings are coatings for metals where the part surface is converted into the coating with a chemical or electro-chemical process. The most significant of these coatings are Cr(VI) and phosphate conversion coatings together with electro-deposition coating. The high anticorrosion performance of Cr (VI) coating is due to its high self-healing behavior in corrosive environment.

However, Cr (VI) compounds have found to be extremely toxic and their usage has been banned. Phosphate coatings are also toxic. Also, the bath containing these materials leaves a huge amount of sludge. Cr (III) is another option which is less toxic compared to Cr (VI) but it doesn't ensure a long term protection. Nanotechnology has been applied to decimate these disadvantages. A three layer system consisting of zinc layer, Cr (III) enriched layer and a layer of nano-SiO2 particles is used for this purpose. Each layer has a specific role in the protection of steel. Zinc has a higher negative potential than iron. When it is exposed to a corrosive electrolyte, it produces electrons needed for cathodic reaction and prevents iron from oxidation. As a result, Zn cations produce positive charge at the surface. Whereas, SiO2 nanoparticles have negative charges. These hence migrate to the corroded area and deposit on it. This phenomenon is called self-healing by nano-passivation.

Nanotechnology for tires

Tire performance depends on its cover composition as it is in continuous contact with the road. The composition of rubber plays an important role in its properties. Different properties like abrasion resistance, grip and resistance against tear propagation are important. Incorporation of 30% filler can improve such properties. Type and loading of filler as well as chemical and physical interactions between the filler and rubber are influential parameters [4][5].

While the tire resistance against grip should be high, its rolling resistance has to be low. Also the resistance should not be so low that it allows for car slide. However, reducing friction can negatively influence car safety.

Soot (carbon black), silica and organosilane are the important examples of materials used to enhance rubber properties. Adding such materials to rubber composition at nanometric dimensions can significantly improve tire properties. The size and surface modification of the particles can affect their chemical and physical interactions with the rubber matrix. This varies the particles cross-linking with natural rubber molecules, affecting its properties. Nano sized soot particles can significantly enhance tire durability and fuel efficiency. These particles have coarser surface due to their higher surface energy, hence produce stronger interactions with rubber matrix (Fig.3). As a result, inner friction can be reduced which results in better rolling properties [4][5].

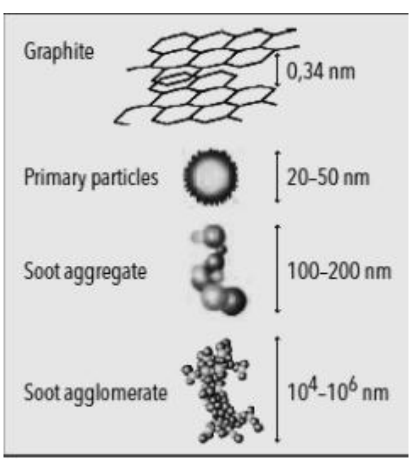

Figure 3: Size comparisons of individual particles of tire running surface

It is known that strain vibration will occur within tire material at high car speed. Nanoparticles can reduce this strain vibration and results in superior traction, especially on wet roads. The surface modification of the particles is important which will affect their interaction with rubber matrix and its final properties. It has been found that carbon nanotube (CNT) can improve mechanical properties such as tensile strength (600%), tear strength (250%) and hardness (70%) of styrene-butadiene rubbers. Tires with higher stiffness and better thermoplastic stability can be produced using lamellar nano-sized organoclays like montmorillonite. The other nanoparticles used to enhance car tyre properties are nanoalumina, carbon nano fibers (CNF) and graphene.

The rolling resistance of tyres can be significantly improved using silane-treated silica compared with traditional carbon black based tyres. As a result, the stopping distance of car on wet roads can be reduced by 15-20%. Also there is a reduction of 5% in fuel consumption [4][5].

Conclusion

Automobile industry is set to be influenced by the development taking place in the field of nanotechnology. Due to the small size of nano-materials, their physical and chemical properties (e.g. stability, hardness, conductivity, reactivity, optical sensitivity, melting point, etc.) can be manipulated to improve the overall properties of conventional material. Nanotechnology is science and engineering, and it is all about practical applications of physics, chemistry and material properties. Nanotechnology will influence the auto industry initially on a very small scale, but will certainly be developed to deliver features, products and processes that are almost unimaginable today.

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