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The Role of Nanotechnology to Combat Major Recent Worldwide Challenges

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Abstract

There are a number of challenging problems facing humanity today. One major challenge is the ongoing Coronavirus disease (COVID-19) pandemic started in late 2019. A second major challenge is the environmental crisis due to fossil fuels combustion causing an increase of greenhouse gases in the atmosphere. While the first challenge seems to be a temporary remedy for the second one, due to less travels by individuals, the actual solution of both problems may require comprehensive scientific, technological, and socioeconomic decisions. In this report, we look at the role of nanotechnology and nanoscale materials towards the solution of these two major challenges.

1. Introduction

Since late 2019 one obvious major concern all around the world has been the problems associated with the Coronavirus disease (COVID-19) pandemic. This disease is certainly one of the biggest challenges of the *21st* century for the whole world. All viruses, including Coronavirus, are nanoscale entities. Coronavirus has a spherical or elliptic shape (Figure 1), and it is said to also assume pleomorphic (irregular and variant) form at various conditions. It has a diameter of about 60-140 nm [*https://www.ncbi.nlm.nih.gov/books/NBK554776/*] which is close to the range of nanoscale (1-100 nm) sizes [1].

It is not surprising that there has been a great deal of interest in finding applications of the principles of nanotechnology combined with biotechnology to combat the virus which causes this disease. In the literature related to developing mRNA COVID-19 vaccines, it is stated that lipid nanoparticles, which had been in the works for decades, are used as delivery vehicles, accelerating the development of these vaccines to save humans' lives [2].

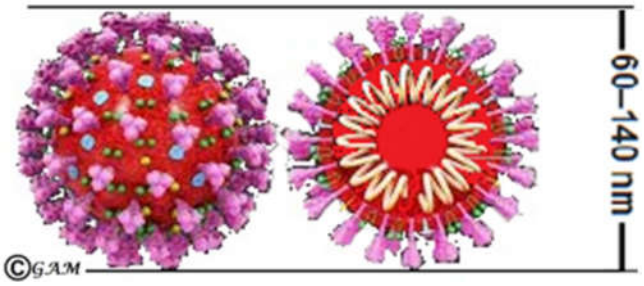

Figure 1. Coronavirus is a nanoscale entity

2. Recent Problems and Efforts Towards their Solution

2.1. *Coronavirus Disease (*COVID-19*) Pandemic*

It is known that, these medical interventions use nanotechnology to mimic nature's own method of slipping past the immune system to deliver treatment to target cells [3, 4]. It is recommended that this technology for delivering vaccines into the human body should be considered by researchers, if the gene editing system for genetic disease treatment using the CRISPR (*Clustered Regularly Interspaced Short Palindromic Repeats*) tool [5], is to have any success in the future. While such scientific efforts seem quite useful in the design of vaccines, there is also a need for reliability studies of the vaccine effectiveness, similar to what has been done for nanodrug delivery [6, 7], in regard to its duration of produced immunity and the possible requirement for its repetition or booster shots.

In addition to efforts to develop vaccines based on nanotechnology, there have been other recent nanotechnology-based efforts to make people more immune from COVID-19, the current most important public health problem. In addition to the recommendation for social distancing we are encouraged wearing facial and hands protection (Figure 2).

Figure 2. Facial and hands protection covers

Such requirement against COVID-19 and other surfaces and airborne pathogens, brought about the design and production of nanotechnology-based facial and hands protection. Nanofibers and nanoparticles have been considered for the design of some face masks to improve their antiviral performance. With the discovery of a variety of nanoparticles (carbon nanotubes, diamondoids, fullerenes, graphene, gold nanoparticles, quantum dots, silver nanoparticles, titanium dioxide nanostructures, etc.), there lies a vast field of unsolved medical diagnoses to be reassessed [8]. Before application of nanoparticles in the design of face masks and other protective devices, in addition to their role in killing the bacteria and viruses, it is important to know what happens to a particle once it is free in the body [9].

Considering the popularity of graphene, a novel nanomaterial, which has found interesting applications specially in *opto-electronics* area [10, 11], some groups have also considered graphene as a novel nanomaterial which, apparently, possesses antiviral and antibacterial properties. Then, there were face masks designed, manufactured and sold containing graphene with protection against COVID-19 claims and used by adults and

children in certain schools and daycares. However, on April 2, 2021, Health Canada, the Department of the Government of Canada responsible for national health policy, issued an advisory mentioning "Face masks that contain graphene may pose health risks". But on July 13, 2021 they issued another advisory update mentioning "Graphene face masks *manufactured* by Shandong Shengquan New Materials Co. Ltd. can resume sale in Canada; Health Canada found no health risks of concern with these products" [*Face masks that contain graphene may pose health risks - Recalls and safety alerts (healthycanadians.gc.ca)*]. There is still this question "whether graphene-coated face masks are a COVID-19 miracle – or another health risk?" by health professionals [*theconversation.com/are-graphene-coated-face-masks-a-covid-19-miracle-or-another-health-risk-159422*].

That is because there is a potential to inhale graphene particles present in the mask, which may pose health risks. Carbon atoms at the edges of a graphene sheet (Figure 3) have special chemical reactivity if they are not properly reacted. Graphene has the highest ratio of edge atoms of any allotrope, including its own allotropes, which include carbon nanotube, nanodiamonds, and Fullerene.

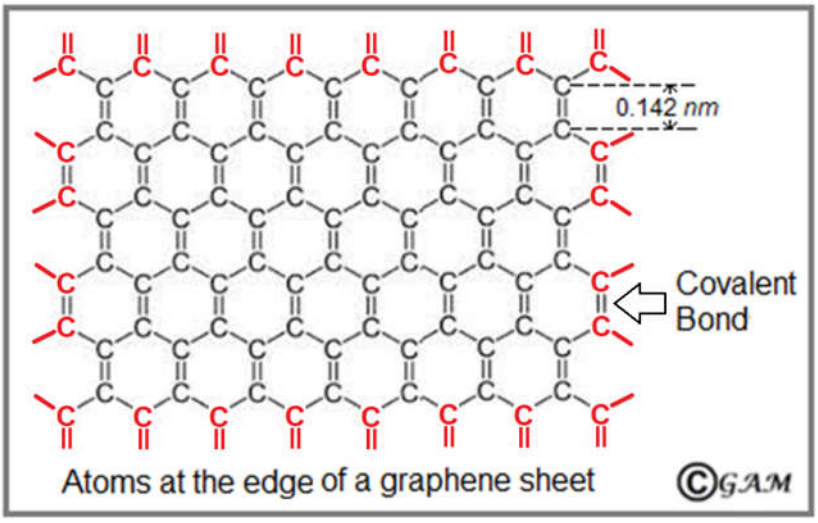

Figure 3. Graphene has the highest ratio of edge atoms of any allotrope

Previous studies have shown that pristine or unmodified carbon nanotubes can cause pulmonary fibrosis/lung scarring and lung inflammation in animals and cellular models after inhalation exposure in a similar way as asbestos [12]. However, studies indicate that graphene could be used as an electronic biosensor to make quick, reliable tests for viruses like SARS-CoV-2. In a recent review [13] investigators looked into the latest research to find the most exciting potential applications of graphene in point-of-care tests. This includes diagnostic tests for the virus responsible for COVID-19, but also detecting other viruses, bacteria and even cancerous tumors.

It should be mentioned that various investigations have indicated that TiO_2 nanostructures [14] and silver nanoparticles [15, 16], among other nanosystems are also effective to combat the bacteria and viruses. Consideration of these and other nanostructures in the design of protective human shields requires carefully analyzed in terms of efficacy and possible long-term effects on the wearers' skin and lungs as well as on the environment [17].

2.2. *Environmental Crisis due to Fossil Fuels Combustion*

While all the countries around the world are trying to combat the COVID-19 pandemic, the earth's environment is being damaged due to the excessive amount of fossil fuels combustion and oversupply of greenhouse gases in the atmosphere [18]. This has made many industrially advanced societies consider abandoning fossil fuels for combustion and utilizing the renewable energies.

The United Nations 26th Climate Change Conference of the Parties (COP26) was held during Oct. 31- Nov. 12, 2021 in Glasgow, UK (Figure 4). Participating 197 countries in COP26 made notable commitments to the Glasgow Climate Pact, but they still fell short of the action needed to keep global warming within manageable levels. The result of COP26 known as "the Glasgow Climate Pact", was the first climate deal to explicitly commit to reducing the use of coal. It encouraged more urgent greenhouse gas emissions cuts and promised more climate finance for developing countries to adapt to climate impacts.

Figure 4. Logo of the 26th Session of the Conference of the Parties (COP26) held during Oct. 31- Nov. 12, 2021 in Glasgow, UK, a picture of the kind of meetings held and a couple of symbolic images about the aim (ALL in FOR 2.5°C) and what is happening to the Earth due to climate change

We published a comprehensive book covering the subject of energy sources, utilization, legislation, and sustainability a year after the COP21 Paris Agreement, which represents a roadmap to follow its requirements [19]. In the book, there are discussions on the role of nanotechnology and nanoparticles in improving the sustainability of the energy industry. Several industrially advanced countries have plans to abandon the use of fossil fuels combustion and utilize renewable energies. While the technology for small-scale renewable energies utilization is already available, for its large-scale utilization, storage and transport of appropriate fuels are required.

In a recent publication [20], we have studied the potential of various non-fossil/alternative fuels for large-scale renewable energy sources utilization. Our studies indicate that production of biofuels using renewable energies will allow biofuels direct use in the existing internal combustion engines. Then, there may be no need for major electrification of the transportation industry which will require a huge amount of expensive and rare materials, such as lithium and silver, to have high-capacity batteries [20]. However, for the agricultural activities based on which biofuels are produced there is a need for ammonia, an important agro-chemical since it is the major feed for agricultural fertilizers. It is interesting to note that ammonia can be also produced using renewable energies as it is demonstrated in Figure 5. However, there are nanotechnology approaches being studied for improvement in its

production conditions from renewable energies [21, 22]. Also, in production of ammonia, an important agro-chemical, from renewable sources of energy, hydrogen is also needed to be produced using renewable energies (Figure 5).

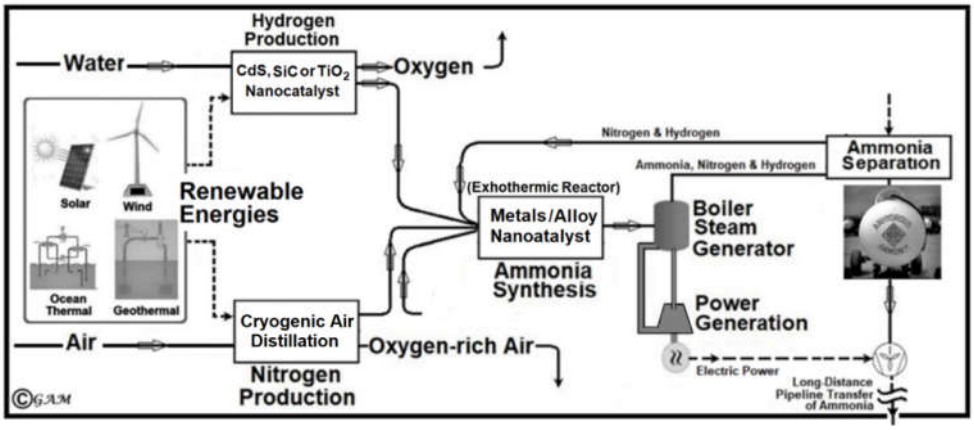

Figure 5. Hydrogen production through dissociation of water, nitrogen purification through cryogenic distillation of air and ammonia (an important agro-chemical) production, storage and transport, all through the use of renewable energies

There are several efforts underway to apply certain nanomaterials for improvement of hydrogen production from renewable energies, as well as its storage and transport in case of using it as a fuel in the future [23-25]. The technology for storage and transport of ammonia is already available worldwide.

3. Challenges and Opportunities

Research and development in the fields of nanoscience and nanotechnology already have produced very useful qualitative and quantitative methods and devices to deal with various problems, especially in the fields of nanomedicine, nanocatalysis, solar energy utilization and design of molecular building blocks/nanoparticles with various potential for applications. In this report we have presented the basic role of nanotechnology to combat the two major world challenges.

Conflicts of Interest

The author declares no conflict of interest.

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