ZnO nanoparticles and their properties as surface coating materials against coronavirus: viewpoint

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A pandemic of coronavirus infection is causing a significant public health hazard globally, putting millions of people at risk in an increasing amount of countries. Nanostructured materials have been recognized to be highly efficient against coronaviruses. ZnO nanoparticles possess unique features that enable to act as anti-bacterial and anti-viral. Hence, the aim of the current investigation is to produce zinc oxide nanoparticles and utilized as surface coating materials against COVID-19. Thermal decomposition has been utilized in this investigation to fabricate ZnO nanoparticles with crystallite of 41 and 55 nm. The study outcomes demonstrated that Zinc nanoparticles is a favorable material for future usage as an anti-coronavirus surface due to their ecologically friendly features and exceptional physical and chemical functionality.

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Keywords: ZnO, nanoparticles, Coronavirus, Coating, XRD, SEM, Fabrication

1. Introduction

Recently, the advent of novel viral diseases has presented a severe danger globally. Several viral illness epidemics have been recorded, including SARS and Ebola. [1]. The World Health Organization (WHO) recognized this virus as a novel coronavirus in 2020. The novel coronavirus is accountable for numerous illnesses and has posed a severe threat to public health globally. [2]. Coronaviruses, belonging to the Coronaviridae group, are responsible for transmitting respiratory illnesses in animals, including bats and camels [3]. The name "coronavirus" is derived from its crowned appearance shape. The virus is called an "inherited corona" since it is encoded by genetic material inherited from the coronavirus itself, a well-known "viral corona [4]. Coronaviruses that have not yet been infected or infected by the host can be covered by a layer of dissolved biomolecules that can be one or more layers thick after coming into contact with mucosa or entering the host[5]. The term "acquired corona" refers to the layers that have been accumulated because of the environment [6]. Coronavirus disease has a range of health conditions and indicators that are distinctive to each individual patient. Nausea, phlegm formation, breathlessness, and some other signs are among the most common clinical features at various phases of this illness [7]. Meanwhile, COVID 19 has the potential to have a significant impact on the economy, personnel, and businesses, besides to its considerable impact on global health [8]. The consequences could also be important from political, military, economic, social, and environmental perspectives [9]. Nanoparticles are microscopic particles with sizes varied from 1 to 100 nanometers, which have unique features that enable for effective sorption of medications, proteins, and other chemical substances [10]. Nanoscale materials have been used in a broad range of applications, including agricultural research, telecommunications, communication, industry, and medicines [11-13]. Researchers have reported that the SARS-CoV-2 virus can survive on the surface for an extended period [14]. Consequences, the development of

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anti-virus coatings for surfaces as well as air filtration systems can aid in the prevention of infection [14]. Nanotechnology-based technologies can be used to alleviate challenges related to Coronavirus surface contamination because of their distinctive characteristics. [15-17]. Such metallic oxides nanopowder regulated and long-term diffusion of ions affects the antiviral characteristics of surfaces [18-19] Nanostructured materials exhibit unique physicochemical and biological properties compared to macro and microstructure materials. [20]. Among its many applications, nanomaterials have the potential to prevent viral transmission through the air and contact with infected surfaces, as well as the capabilities to disinfect protective equipment, which is particularly useful in healthcare setting[21]. Another technique for preventing the spread of COVID-19 is to design surfaces that are self-disinfecting [22]. However, one of these options is the coating of surfaces with nanoparticles such as silver, zinc oxide, and copper NPs [23-24]. The current investigation is focused on the prospect of employing zinc oxide nanoparticles as surface disinfectants against COVID-19.

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2. Materials and methods

2.1. Synthesis and characterization of ZnO nanoparticles

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2.1.1.1. Production of ZnO nanopowder (55 nm)

Zinc acetate dehydrates [Zn (CH3COO)$_2$ H2O] 99,99% purity was purchased from Panreac (Spain) and used as a precursor to prepare ZnO nanopowder without further purification. 10 g of zinc acetate dehydrate was placed into the ceramic crucible and calcined at 900 °C for 1 hour in a muffle furnace in the air. Finally, ZnO nanopowder was obtained.

2.1.1.2. Production of ZnO nanopowder (41 nm)

ZnO nanomaterial was prepared via the thermal solid-state method using zinc oxide as a precursor (Panreac Spain). The approach is based on the calcination of bulk zinc oxide at 120 °C for 2 hours to obtained ZnO nanopowder.

3. Result and discussion

3.1. XRD analysis

ZnO nanopowder structure was examined via X-ray diffraction patterns. The results are presented in Fig.1 and shown broad peaks at positions (32.08, 34.73, 36.54, 47.90, 56.88, 63.19,68.12, and 69.29 deg. as 2 thetas). Indeed, these peaks are identified as (100), (002), (101), (102), (110), (103), (200), (112), and (201) plans of hexagonal wurtzite structure of ZnO. The average crystallite size (D) was calculated using *Scherer's* equation below.

$$\mathrm{D} = \frac{0.9\,\lambda}{\beta cos\theta}$$

where λ the wavelength of Cu Kα radiation is, β is the full width half maxima (FWHM) of the diffraction peak and θ is the Bragg peak angle. Obviously, we can see that the peak intensity of the nanosize 40.9 appear to be higher than the intensity peak of the nanosize 55 as shown in the XRD pattern. From the *Scherer's formula* the average crystallite size was found to be of 55 nm for ZnO obtained from Zinc acetate dehydrate and 41 nm for the ZnO obtained from Zinc oxide. It obviously shows the presence of nano-sized particles in the samples[ ].

3.2. The scanning electron microscopy (SEM)

SEM is a highly effective technology for topographic examination of nanopowder materials. It contains valuable information regarding the nanopowder's shape and structure. SEM images were acquired in the current investigation utilizing a high-performance scanning electron microscope JSM-6380 with a resolution of 3.0nm. Fig. 2and 3 illustrates the surface morphology of ZnO nanopowder at various magnifications for both sizes. SEM pictures reveal that ZnO nanopowder has a non-uniform shape, with clusters of granules appearing as scattered blocks, as indicated in figure (2). Regarding the appearance of the sizes in the two figures, it is noted that they are similar to the sub-clusters of grapefruit. Figure 4 and 5: presents a three-dimensional image of zinc oxide nanoparticles surfaces, from the figures it can be seen that zinc oxide is growing laterally as a rod, in general, is not aligned in one direction. The SEM image clearly verifies the obtained ZnO nanoparticles.

3.3. Anti-surface coating for Coronavirus

Nanoparticles are crucial for avoiding virus contamination from the air and contact with diseased surfaces, which may be particularly useful in sterilizing protective equipment and in the hospitals and schools [25]. Moreover, nanomaterials possess electrical and optical properties that have been extensively investigated in the development of biosensors applications [26]. Zinc is one of the most frequent trace metals found in the human body, and it plays a key part in the operation of cells[27]. Zn has minimal cytotoxicity and has been demonstrated to influence a variety of cell death controllers [28]. A number of anti-virus actions have been demonstrated for zinc, and it has been hypothesized that zinc may aid in the enhancement of lymphocyte responses to gene transcription and their bio-molar activity. [29-30]. ZnO nanoparticles (ZnO-NPs), over other metal oxide nanoparticles, have 3.2 eV large bandgap, its microcrystals are extremely effective light absorbers in the ultraviolet region of the spectrum and categorized as a semiconductor [31]. Although, the majority of ZnO-NP research has focused on their antibacterial activities, only a few researchers have examined their interactions with viruses [32-33]. However, a recent study demonstrated that ZnO-NPs are effective versus a wide range of infections including viruses [34]. ZnO-NPs have bioactive inhibitory effects on SARS-CoV-2, which is considered one of the most difficult viruses to combat when it comes to human health [35-37]. Therefore, ZnO nanoparticles can act as candidate materials for coating to eradicate the coronavirus due to their novel characteristics [38-39]. Figure (6) displayed the coronavirus structure and its essential components, which included the spike protein, the nucleocapsid protein, the hemagglutinin esterase glycoprotein, the viral genome RNA, the envelope protein, and the membrane protein [40]. The present work is built on a hypothetical basis according to published studies[41-44]. The primary theme of article is based on on coating the glass wall or any leather surface with ZnO nanoparticles in order to eliminate the infection of the Coronavirus. A linker material was used to stick the ZnO nanoparticles to the glass leather surface, Afterward, ZnO NPs was dispersed in an alcohol solution and then spread on the glass and leather surface to form a layer of zinc oxide nanoparticles. Zn2+ ions have a possible inhibitory effect on viral reproduction by increasing the content of intracellular Zn2+, which can effectively limit the replication of some RNA viruses [45-47]. This related with the fact that ZnONPs produce Zn2+ ions as well as different kinds of reactive oxygen species, and that these free radicals can destroy proteins, lipids, carbohydrates, and DNA, ultimately resulting in death as shown in figure (7) [48 -49]. The influence of zinc oxide on biological function is dependent on the morphological nature, size of particles, and period of exposure, dosage, and biocompatibility [50]. Furthermore, many of reports revealed that ZnO-NPs' ability to act as a disinfectant against the SARS-CoV-2 pathogen [51-52]. ZnO nanoparticles efficiently capture viral via a novel virostatic mechanism, preventing them from passing through corneal fibroblasts cell [53].Due to their potential to inactivate viruses, ZnO-NPs is a promising material for future usage as an anti-coronavirus surface due to their ecologically friendly features, unique physical and chemical functionality

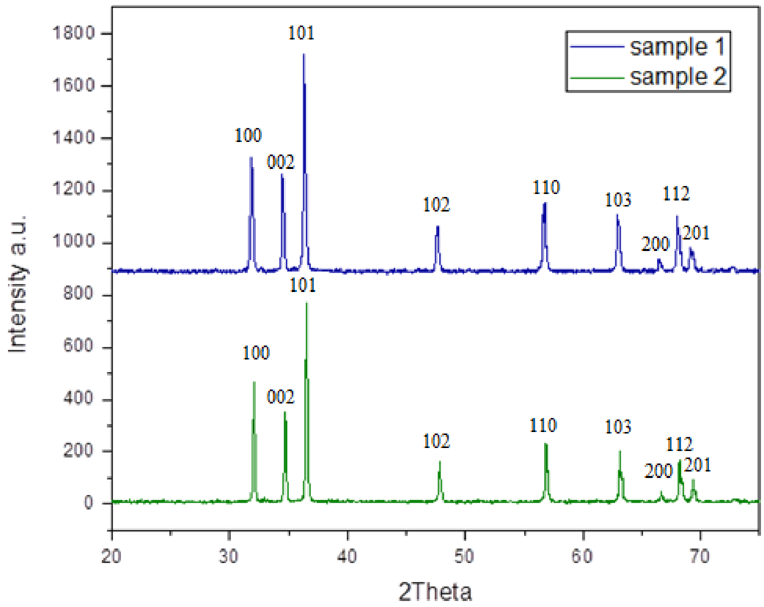

Fig. 1. XRD patterns of ZnO nanopowder synthesized by thermal decomposition method for both sizes 55nm and 41nm.

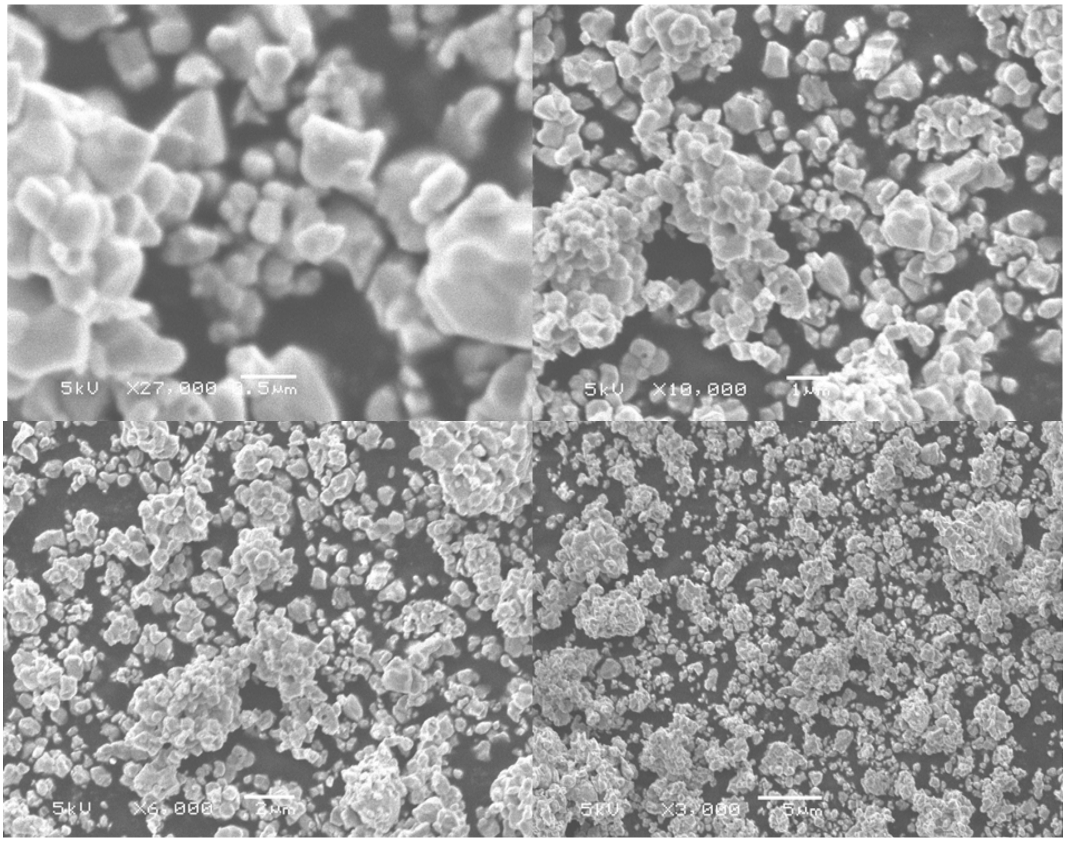

Fig. 2. SEM (2D) image of ZnO nanopowder 55 nm at different magnifications.

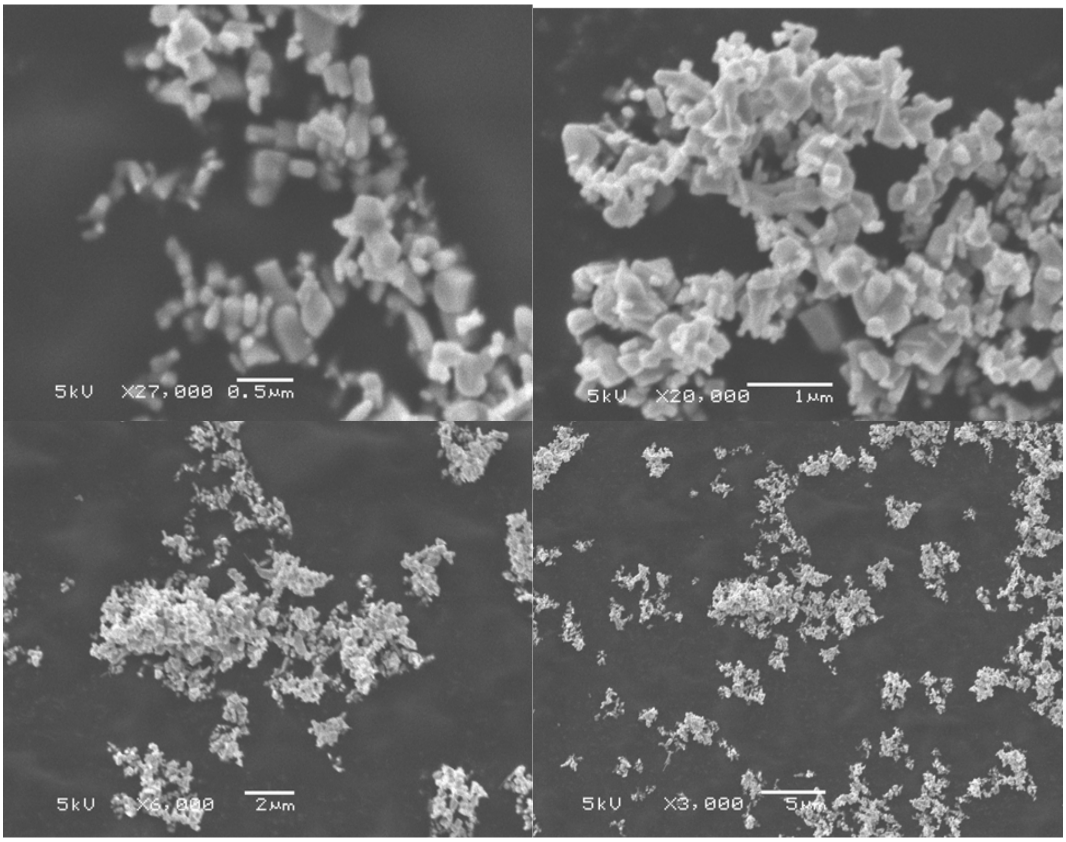

Fig. 3. SEM (2D) image of ZnO nanopowder 41 nm at different magnifications.

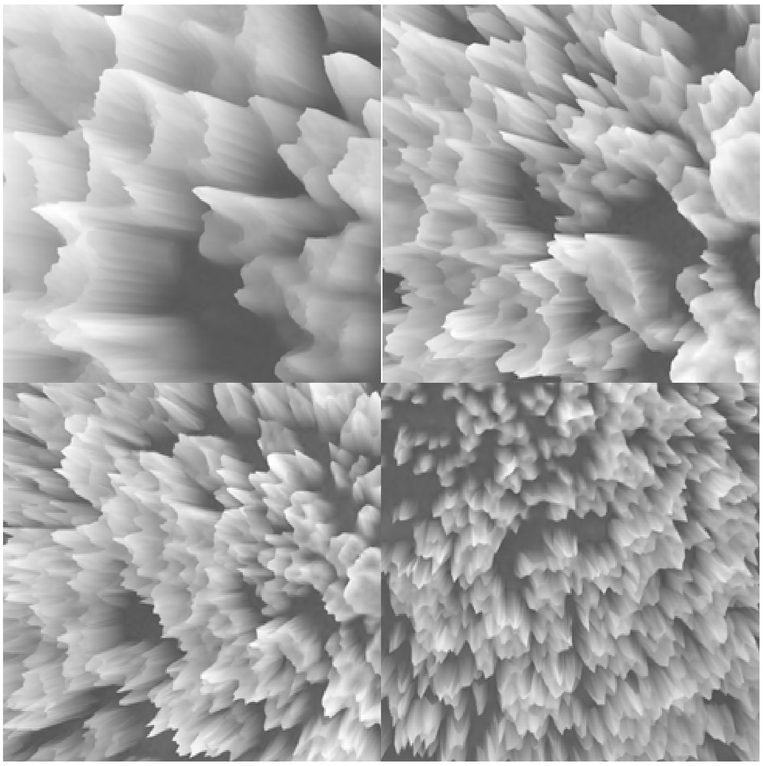

Fig. 4. SEM (3D) image of ZnO nanopowder 55.nm at different magnifications.

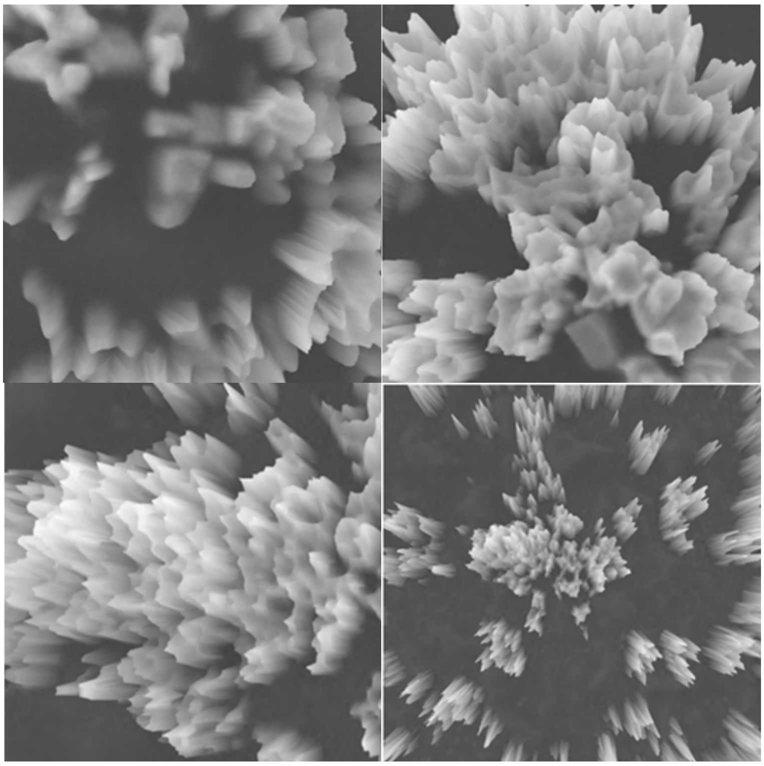

Fig. 5. SEM (3D) image of ZnO nanopowder 41nm at different magnifications.

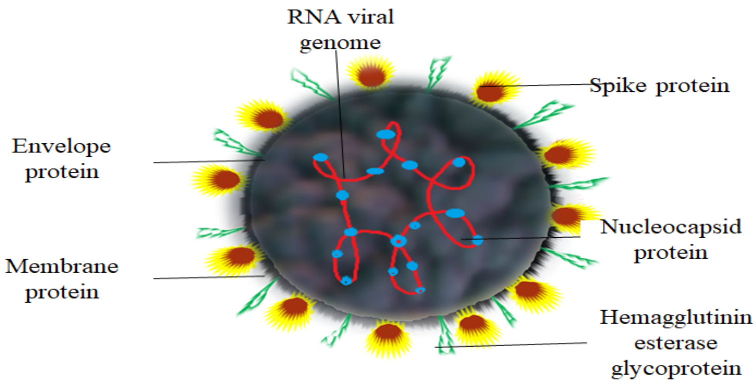

Fig. 6. Schematic diagram of a virus structure based on coronavirus.

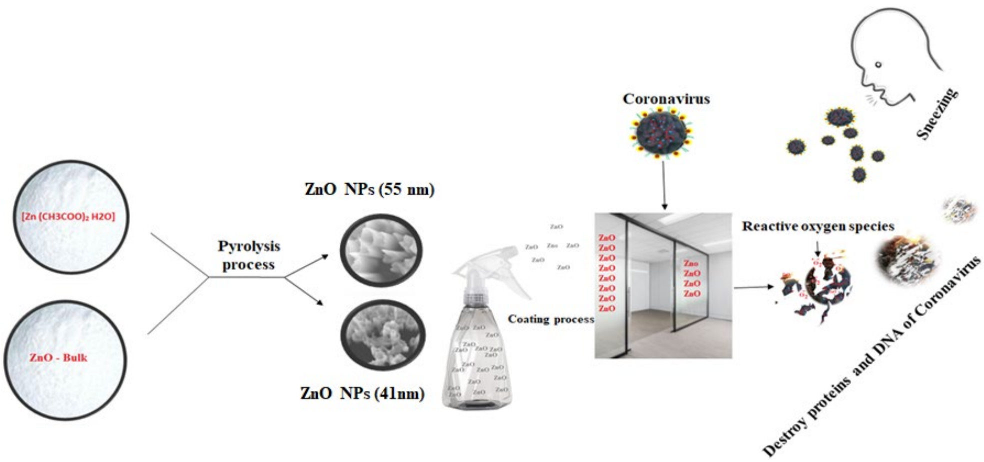

Fig. 7. Mechanism of eliminating the coronavirus by coating the surfaces with nanosized-zinc oxide.

4. Conclusions

The present work sheds light on the fabrication of nanosized ZnO using inexpensive and simple approaches, as well as their usage as surface disinfectants against the COVID-19. The study outcomes revealed that the ZnO NPs was obtained with crystallite size of 41 and 55 nm. The ZnO NPs coating was shown to be a promising material for future usage as an anti-coronavirus surface due to their ecologically friendly features, unique physical and chemical functionality.

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