**Role of plant based MeONPs in Nanotechnology for manufacturing of Protective Masks**

Y.V.N. Damodara Rao1, Praveen Kumar Nagadesi2\*

1Department of Physics, Anurag Engineering College, Ananthagiri, Suryapet (Dist), Telangana-508206.

2Department of Botany, School of Life Sciences, St. Joseph’s University, Lalbagh Road, Bengaluru - 560027, Karnataka, India.

\*Email: nagadesipraveenkumar@yahoo.com

**Abstract:**

As per the underlying precaution provided by the WHO, which recommends the usage of a facial mask to contain the COVID-19 pandemic, several countries have made it mandatory to wear a face mask in public areas.

The most commonly used face masks and respirators are surgical masks and N95-level respirators, which are fabricated from synthetic or natural polymers or composites. In general, face masks and respirators consist of three layers, out of three middle layer is the most important layer with regards to protection from particles or droplets carrying viruses and bacteria, and the remaining two external layers are fabricated with nonwoven melt blown polypropylene and spun bond polypropylene and also some N95-level respirators have additional layers for better protection.

Now-a-days nanomaterials have become one of the most advanced research fields in different disciplines like solid-state physics, chemistry, engineering, and biology. Applications of nanoparticlesin biomedicine are steadily increasing day by day because of their ease of functionalization that improves their stability and compatibility. Recently, the development of inorganic nanomaterials such as metallic-based nanoparticles, superparamagnetic iron oxide nanoparticles, and quantum dots has also generated attention for biomedical applications.

The present work gives a detailed explanation about synthesis of metal and [metal-oxide](https://www.sciencedirect.com/topics/materials-science/metal-oxide) nanoparticles, especially by biogenic method, and their applications. If we use this kind of nanoparticles grown in special condition while manufacturing protective masks which leads to provide better leak protection and filtration performance and also provides information on the usability of the nanotechnology enabled protective face masks is compared with that of currently available commercial grade masks.

**Keywords:** nano-metal-oxides, biogenic, protective masks.

**Introduction:**

Plant materials products like fungi and sometimes microorganisms for nanoparticles fabrication are eco-friendly. Since these materials are easily available and do not require organic solvent as reaction medium and also, they are easy to handle and economical.

The plant-based synthesis of nanoparticles (MeONPs) is advantageous over chemical, physical and or microbial synthesis as it removes the complicated protocol and can also meet the large-scale production requirement. The synthesis of Nanoparticles by chemical or physical methods requires fairly large amount of toxic chemicals which leave undesirable materials into environment. Because of not capped or coated expensive chemicals, nanomaterials are not protected and are relatively less stable than those produced by plant-based materials.In most of the cases the NMs thus synthesized are capped by biomolecules like phenols, tannin, flavonoids and ascorbate present in the plant materials.

The noble metal NPs such as silver, platinum, gold and their alloys have been frequently biosynthesized by various workers. Among the MeNPs, copper nanoparticles (Cu-NPs) are of great interest due to their availability, low cost, and high electrical conductivity.when Copper nanoparticles integrated in coatings and textiles are used as an antimicrobial, antioxidant and anti-inflammatory.

Based on the current information an attempt has made on role of plant based MeONPs (CuO-NPs) in Nanotechnology for manufacturing of Protective Masks. The present review is also focussed on the impact of size of MeNPs and MeONPs and their efficiency as antibacterial and antiviral agent.

**Herbal Extracts or Bio-Based Substances:**

Herbal Extracts Herbs or Bio-Based Substances have been used in medicine since ancient times, including for the purposes of treating wounds which in advertently protected them against microbes long before the emergence of germ theory. Studies have shown that herbal extracts are effective against viruses including human immunodeficiency virus (HIV), respiratory syncytial virus (RSV), and SARS-COV, all of which can cause severe pneumonia. In particular, licorice extracts such as glycyrrhizin (GL) and glycyrrhetinic acid (GA) have been demonstrated to be sutable to destroy biomolecules and possess antiviral properties, primarily by either preventing contagions from replicating or by inactivating them altogether. Due to the antiviral property the licorice can be used for manufacture plant based protective masks to inactive SARS-COV-2 and also thwart the spreading of COVID-19. Chowdhury et al. combined licorice root extracts containing GAA and GLZ with the electrostatic spinning process to manufacture a licorice root nanofiber membrane, which can be used as the filter layer in the fabrication of antiviral protective masks. The diameters of the nanofiber in the licorice root membrane ranging from 15 to 30 μm with random porosity and direction.

Besides licorice extracts, it was also found that some herbal plants like sage, garlic, oregano, fennel, etc., containing with antimicrobial properties can reduce some symptoms of infectious individuals and they may prevent the transmission of COVID19. In addition to this an Activated Carbon Fiber (ACF) filter incorporated with Sophora Flavescens, developed by Sim et al. and they recorded the antibacterial efficiency of ACF filter showed greater than 90%. But, the heavy load of herbal extracts in filters may result a significantly increased pressure drop. To Rectify this problem, an antibacterial nanofiber membrane was introduced by Choi et al. and that were prepared by a solution of polyvinylpyrrolidone (PVP). As in polymer nanofibers the antimicrobial components are uniformly distributed, the composite nanofiber filter paper was able to obtain 99.98% of an antimicrobial activity against S. epidermidis and 99.99% of filtration efficiency.

**The Possible Antiviral Action of Metal Nanoparticle (MeNPs):**

**Copper Nanoparticle:**

As from the earlier reports the oxidized copper nanoparticle (CuO NPs) is a well-known catalyst and have the capacity to reduce the bacterial and virus population. The study report suggests that Cu2+ ion because of increased oxidative stress shows antiviral potential against all types of viruses such as HIV-1, influenza, herpes simplex virus. The antiviral activity of copper (I) iodide (CuI) nanoparticle (160 nm) against H1N1 influenza confirmed through plaque titration evaluation indicated by Fujimori et al. Experimental results indicate nanoparticles at a concentration of 17 micro gram per ml over an incubation period of 1 h produces dose-dependent reduction of virus titer. The probable mechanism of virus inactivation is related to inactivation of surface glycoprotein such as HA and NA by hydroxyl radials.
Another study on vero cell line reveals an excellent antiviral potential of CuO NPs of size 40 nm.

Along with antiviral effect, copper nanoparticle could be useful in the preparation of safe and effective personal protective equipment (PPE) such as protective face mask, respirators, hair cups, etc. copper NPs have been reported to cause toxicity irrespective of its positive outcomes. CuO NPs are size-dependent, it is shown from the literature revealed cytotoxicity and genotoxicity in C57BL/6 mice cell line. Later toxicological findings suggest inhalation of CuO NPs induces pulmonary inflammation and fibrosis in a dose dependent manner.

In another study, it was found that intra tracheal instillation CuO NPs of size 33 nm induces acute toxicity, inflammation and edema in F344 male rats. Due to distinct advantages of copper NPs against respiratory pathogens could make a significant impact in the management of Covid-19 regardless of the size-dependent toxicity.

A study showed a nanocoating mixture of Cu NPs and shellac assisted with two-channel spray was applied to a nonwoven surgical mask hence the surface’s hydrophobicity means ability to repel water droplets increase. Then the surfaces show excellent photothermal properties and photocatalytic with antimicrobial properties and which make the masks reusable and able to self-sterilize. Under sunlight, the temperature of this photosensitive antiviral masks rises quickly to greater than 70 °C, which produces high concentration of free radicals and they can destroy the membranes of nanoscale (≈100 nm) virus-like particles.

Ahmad et al. showed that CuO NPs release copper ions that can act as a catalyst to create reactive oxygen species, thus destroying the integrity of capsid of herpes simplex virus (HSV) and degrading the whole genome.

Gadi and co-workers reported that by immersing N95 mask in CuO NPs to prepare antiviral respiratory protective masks, CuO NPs attached to the mask could kill viruses retained in the mask without changing the physical barrier performance. A study showed that better antiviral performance whenever N95 masks treated with CuO NPs compared to untreated masks by five times. Further, CuO NPs are cheap, chemically stable, and have shown extensive antibacterial properties, making it a popular choice in the production of materials that require antiviral functions.

|  |
| --- |
| **Size dependent antiviral approach of MeNPs and MeONPs:** |
| **S.No** | **Name of Nanoparticle** | **Size (nm)** | **Virus** | **Cell line model** | **Expt. conc** | **Target site for virus inhibition** |
| 1 | CuI NPs | 160 | Influenza A virus | MDCK cells | 50% reduction of virus titer@17 μg/ml | Inactivation of viral protein |
| 2 | CuO NPs | 40 | Herpes simplex 1 | Vero cell | 83% of viral load | Interfere the viral replication |

|  |
| --- |
| **Comparative antiviral/antibacterial performance ofbio-based and metal-based masks:** |
| **S.No** | **Bio-based/herbal extracts** | **Preparation** | **Performance** |
| **1** | Licorice | Extraction | The capture and inhibition properties of licorice root cause rapid inactivation of the virus. |
|  |
| **2** | Herbal Extract Incorporated Nanofiber Fabricated | Electrospinning | With 99.99% filtration efficiency and 99.98% antimicrobial activity against Staphylococcus epidermidis |  |
|  |  |  |  |  |
| **S.No** | **Metal-Based particles mask** | **Preparation** | **Performance** |  |
| **1** | Au nanoparticles (NPs) | Chemical reduction | 92% viral infection reduction after 6 h |  |
| **2** | Ag NPs | Electrochemical | The cell survival rate reaches 98% after the infected cells cultured in 100 ppm Ag NPs for 48h |  |
| **3** | Ag2O|AgO NPs | Algae biosynthesized | 90% reduction in cytopathic effect (CPE) of HSV-1 after applying Ag2O/AgO NPs and Au NPs |  |
| **4** | Cu NPs | Coating | Under solar illumination, rapidly increase to >70°C and destruct the membrane of nanosized (∼100 nm) virus-like particles |  |
| **5** | CuO NPs | Surface modification | Five orders of magnitude improvement in killing viruses compared to N95 |  |
| **6** | TiO2 | Sonochemical | Extraordinary antiviral efficiency against NDV at a certain concentration |  |
| **Comparative mechanismsof bio-based and metal-basedantiviral/antibacterial materials in Masks:** |
| **Mask Type** | **Principal mechanisms** | **Advantages** | **Disadvantages** |
| **Bio-based/herbal extract** | Licorice extracts | Prevent viruses from replicating or inactivate them. | Low toxicity, high antimicrobial activity, mild environmental effect and low cost | Durability remains a concern |
|  |
| Some other herbal Extracts | The contained flavonoids kill microorganisms by disrupting cell membrane function and inhibiting DNA cyclase. |   |   |  |
| **Metal-Based particles mask** |   | 1) Inhibit attachment of the virus.  |   |   |  |
| 2) Produce highly reactive oxygen, ions and free radical species.  |  |
| 3) React with microorganisms and potentially destroy the virus structure and disrupt reproduction.  |  |
| 4) Activate the immune response of infected cells by simulating their nucleus |  |
|  | Au NPs | Inhibit attachment of the virus | Excellent stability, biocompatibility and bioconjugation. | Expensive |  |
| Ag NPs | Inhibit attachment and penetration of virus | Much cheaper than gold and can be widely used in textiles, medical equipment and wound dressing materials. | Need further study of practical face masks performance. |  |
| Cu NPs | Destroy the membranes of virus thanks to excellent photoactivity | Much cheaper than gold and silver | Potential risk of burns under sunlight. |  |
| CuO NPs | Destroy the integrity of capsid of virus and degrade the whole genome | Cheap, chemically stable and have shown extensive antibacterial properties. | Need to be further studied |  |
| TiO2 | Destroy the lipid membranes of viruses and block attachment. | Need to be further studied. | Need to be further studied. |  |
| ZnO | Prevent entry of viruses. | Need to be further studied. | Need to be further studied. |  |

**Conclusion:**

MeONPs have garnered huge attention as a potent antimicrobial, antifungal, anticancer, and anti-inflammatory agent due to their high surface-to-volume ratios compared with their bulky counterparts.

We suggest that nanotechnology could be more useful when implemented with biogenic MeONPs while manufacturing protective masks in present situation.which leads to provide better leak protection, prolong lifetime and filtration performance of mask. Which enables protective face masks is much better than compared with that of currently available commercial grade masks. When looking at the quality of the nanostructured mask there is still research and still opportunities of more research to be conducted. Hence, we Strongly believe this work will be a valuable to the researchers both from the biomedical field and nanotechnology.

**References:**

Apostolov AT, Apostolova IN, Wesselinowa JM. Dielectric constant of multiferroic pure and doped CuO nanoparticles. Solid State Commun. 2014; 192:71–4.

Din MI, Arshad F, Hussain Z, Mukhtar M. Green adeptness in the synthesis and stabilization of copper nanoparticles: catalytic, antibacterial, cytotoxicity, and antioxidant activities. Nano Res Lett. 2017;12:638.

Fujimori Y, Sato T, Hayata T, Nagao T, Nakayam M, Nakayam T et al (2012) Novel antiviral characteristics of nanosized copper(i) iodide particles showing inactivation activity against 2009 pandemic H1N1 influenza virus. Appl Environ Microbiol. https://doi.org/10.1128/AEM.06284-11.

Jain S, Jain A, Kachhawah P, Devra V. Synthesis and size control of copper nanoparticles and their catalytic application. Trans Nonferrous Met Soc China. 2015;25:3995–4000.

Kumar S, Karmacharya M, Joshi S R, Gulenko O, Park J, Kim G H and Cho Y K 2020 Nano Lett. 21 337–43

Lai X, Zhao H, Zhang Y, Guo K, Xu Y, Chen S et al (2018) Intranasal delivery of copper oxide nanoparticles induces pulmonary toxicity and fibrosis in C57BL/6 mice. Sci Rep. https://doi.org/10.1038/s41598-018-22556-7.

Lee Y, Choi JR, Lee KJ, Stott NE, Kim D. Large-scale synthesis of copper nanoparticles by chemically controlled reduction for applications of inkjet printed electronics. Nanotechnology. 2008;19:598–604.

Pariona N, Mtz-Enriquez AI, Sanchez-Rangel D, Carrion G, Paraguay-Delgado F, Rosas-Saito G. Green-synthesized copper nanoparticles as a potential antifungal against plant pathogens. RSC Adv. 2019;9:18835–43

Thiruvengadam M, Chung IM, Gomathi T, Ansari MA, Khanna VG, Babu V, Rajakumar G. Synthesis, characterization and pharmacological potential of green synthesized copper nanoparticles. Bioprocess Biosyst Eng. 2019;42: 1769–77.

Tiwari M, Jain P, Hariharapura RC, Narayanan K, Udaya BK, Udupa N, Rao JV. Biosynthesis of copper nanoparticles using copper-resistant Bacillus cereus, a soil isolate. Process Biochem. 2016;51:1348–56

Umer A, Naveed S, Ramzan N, Rafiqui MS. Selection of a suitable method for the synthesis of copper nanoparticles. Nano. 2012;7:1230005.

Yang S, Wang T, Tang R, Yan Q, Tian W and Zhang L 2020 Int. J. Biol. Macromol. 151 159–67

Zheng XG, Xu CN, Tomokiyo Y, Tanaka E, Yamada H, Soejima Y. Observation of charge stripes in cupric oxide. Phys Rev Lett. 2000;85:5170–3