

Review Article

Nanotechnology based Facemasks to reduce community spreading of Covid-19: An overview

R. Naveenkumar^{1,2,3}, G. Baskar^{2,*}

¹Department of Biotechnology, St. Joseph's College of Engineering, Chennai - 600119, India.

²Biological Systems Engineering, University of Wisconsin–Madison, Madison, WI 53706, United States.

³Forest Products Laboratory, USDA Forest Service, Madison, WI 53726, United States.

*Corresponding author's e-mail: basg2004@gmail.com

Abstract

The (COVID-19) pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is evident in every quarter of the world, airborne pollutants become a peril, deftly spreading viral particles, which enters directly through the nasal and oral cavity into the human system, creating a huge impact on the respiratory system. Every so often through the eyes, which is considered to be a vital cause for increased mortality rate. Effective treatment and a viable vaccine are still under research across various parts of the world, therefore to bring down the virulence on community spreading by airborne pollutants, a self-preventive course of action like using a facemask is suggested as a mandatory deed. Transmission can be reduced by maintaining a social distance, avoiding unnecessary gatherings, but wearing a mask will reduce the risk of getting infected from one person to another. We have tried to evaluate the possible effects of the usage of face masks in combination with proper hygienic practice to reduce the transmission possibility in the current COVID-19 epidemic among a community. This paper discusses the implementation of nanotechnology-based face masks also mainly focuses on the materials and efficiency of the facemasks presently used.

Keywords: Nanotechnology; Filter; Airborne; Facemask; Covid-19.

Introduction

The 21st century has witnessed a pandemic which was priorly witnessed in the year 2009 Influenza H1N1, followed by Severe acute respiratory syndrome coronavirus-2 (SARS-CoV2) commonly known as COVID-19. WHO (World Health Organization) has declared COVID-19 as a global pandemic after many cases were reported all across the world. It is reported that the first case was initially emerged from the Wuhan province in China, in December 2019. It is a single-stranded viral load, reported being derived from SARS related coronaviruses leading to the outbreak of the pandemic, infecting over 12.272 million people with an estimate of about 5,65,138 deaths from 31 st December 2019 to 1st July, 2020, in India the first viral carrier was reported on 30th January 2020, gradually initiated to spread across the entire country. The pandemic had set a record of 5734 cases with 472 recuperations and 166

deaths on 9th April 2020, which is reported to be a slower pace of transmission compared to other countries which reported rapid transmission [1, 2].

The prodrome of COVID-19 turns up only after the 5.2th day. The time taken for the manifestation of symptoms to mortality depends on the individual's immune system, usually, it ranges between 6 and 41 days interval, but commonly reported on an average of 14 days. Senior citizens over the age of 70 and individuals with underlying health issues are more prone to this infection, collate to others who come under this age group and healthy individuals. Dry cough, fever, tachypnea and shortness of breath are the common first symptoms. Comorbidity is a prime issue that elevates the risk of being an easy target for infection [3]. COVID-19 virus which proved to be transmitted mainly through respiratory droplets targets the lower respiratory tract, which

is a susceptible entry for this virus because it has angiotensin-converting enzyme 2 (ACE2) [4]. Severely obese individuals with a BMI of 40 kg/m², existing diabetes mellitus (DM) condition, and hypertension are more vulnerable to COVID-19. According to Muniyappa et al. certain COVID-19, asymptomatic individuals act as carriers, which increases the risk of transmission [5]. A study by Zu et al. has confirmed that the transmission of this virus is mainly by direct contact from one individual to the other or indirectly by coming in contact with the contaminated surfaces, often through the nasal or oral secretions of the infected individuals to their close contacts [6]. To lessen the speed and layout of the transmission, prompt action was carried out as extensive control measures, that impose to close country borders & educational institutions, encourage the remote work, the complete shutdown of the public transport, holds entire nation under curfew, closures of shops, restaurants and holy places, social or mass gatherings ban, advertising the importance of social distancing, educating about self-hygiene such as washing our hands frequently using soap or sterilizing agents, wearing face masks, and mandatory quarantine for individuals who return from overseas and those who are in close proximity to them. The tests to affirm the corona positive or negative were done by reverse-transcription polymerase chain reaction (RT-PCR) [1]. Tele-health service providers were encouraged, psychological support was given to the patients, their kith and kin, and people who work in the healthcare sectors, to eradicate the anxiety and stress caused during the pandemic [7].

Safety Parameters For healthcare workers and community settings

The safety of the front-line workers is a prime responsibility for WHO and the government. A diverse of precautions and safety measures were to be enhanced by the Government and WHO to narrow down the transmission rate and to prevent community spread from COVID-19. The practice of the underneath safety guidelines might have a massive effect on truncating the transmission rate during the epidemic.

Hand-wash / Hand hygiene

Washing the hands, legs, and other possibly exposing areas thoroughly using normal soap &

water or alcohol-based sanitizers like ethanol or isopropanol will reduce the transmission. Persistent hand washings are encouraged as studies revealed that the viruses from certain infected surface/areas may have a chance to unwittingly attached in hands have the possibility to enter the eyes, nasal or oral cavity which leads to the infecting the individual respiratory system. Repeated self-hygiene practices help to fight against novel COVID-19 [8].

Social Distancing

Maintaining a social-distance of about 6 ft from one to another individual may avert from getting infected, which sooner or later breaks the chain of infected individuals. Coughing, sneezing, or talking may release droplets containing the virus in the form of an aerosol, that could possibly enter through the nose or mouth of the person on the other side, results in transmission. Self-isolation is tremendously advocated even if the individual shows minor symptoms, which is more helpful in put a stop to community transmission [9].

Face Mask

The utilization of face masks is requisite among front-line workers and the public, face masks play a crucial role in minimizing the community spread transmission. Cheng et al. have delineated that South Korea and Hong Kong had restricted the transmission without curfew (lockdown) by using the mask imperatively in public. WHO firmly put forward that health-care workers must use masks and protective clothing (goggles and gowns) while treating the infected patients [10]. Considering the current situation of unavailability of vaccines, for COVID-19. Usage of the masks will halt the airborne transmission and controls the community spread. The N95 respirators are one type of face mask certified by the CDC and NIOSH for delivering proper protection against Covid-19 infection. A surgical mask is recorded to be effective in several cases. Most of the respiratory masks have a pore size smaller than the COVID-19 virus thus helps to trap the virus before entering the human body through the nose and mouth [11]. MacIntyre et al. studied the comparative efficacy of cloth masks with medical masks among healthcare workers and concluded that particles penetrated by cloth masks were almost 97% [12].

Types of face mask used in Covid-19

Face masks comes with demarcating designs and unique materials that enhance their filtering capacity, it is believed to be the primary step in personal protective equipment (PPE) to prevent aerosol transmission by contact or droplet transmission. Particularly in health care sectors, face masks that label as PPE has to be unmistakably indulge in safeguarding the person wearing the mask from supposed infectious agents. In accordance with the current pandemic Covid-19 cloth masks, surgical masks, FFP1, FFP2, FFP3, and N95 are prescribed to be commonly used as a first-line defense against droplet respiratory transmission.

Cotton Cloth Mask

Cotton cloth masks are the economical and nominal options for the public, it was labeled as the low-cost and best choice as they are made up of cotton or any fabric that can be taken up within any household items. Cotton cloth masks are reusable multiple times by continual washing. Though these cotton cloth masks are believed to protect against the entry of big droplets and splashes into the airway, these types of masks are not preferred owing to their larger pore size because they could act as a hallway for certain microbes or infectious viral particles to enter the respiratory tract. Since these types of masks are preferably not able to prevent the entry of harmful infectious agents so they are frequently followed by quick hand sanitation using alcohol-based sanitizer or a hand wash using a mild to strong soap and water. The public should be well informed about the proper handling and disposing of methods of the face mask as this can become a potent transmitter during such pandemics.

Surgical Mask

Ever since the evolution of medicinal facilities, the importance of personal protective equipment has been predominantly given. The Surgical masks marked their genesis in the early 90s, developed mainly to prevent infection in the health care sectors as they are much prone to infectious agents which can come in different forms, such as from surgical wounds, anatomical waste from pre & post surgery. Infectious microbes passing via the nasal and oral cavity directly impacting the respiratory system. This

was mainly developed to narrow down the infection rate among the employees working in the healthcare and hospital sectors. Some studies outlined that surgical masks are not as efficacious as respiratory masks [13]. Surgical masks are single-use; it comes with different thickness in three layers made of the molten brown polymer, a polypropylene is fixed in between a non-woven fabric that helps to cover nose and mouth, it provides a primary physical barrier from getting a prominent infection from the environment which mostly contains large-particle droplets, splashes, sprays or splatters into the respiratory tract. The surgical masks block the entry of bacteria present in the droplets and aerosols into the nasal and oral cavity of the individual wearing it. In spite of their good ability, the surgical masks yet are not as effective as respirators when it comes to the impediment of airborne bacteria or viruses from inhalation. In addition to this disadvantage, the surgical masks are single-use, fragile, and fit loosely to the face, so they may allow the air to flow into the nasal or oral cavity [14]. Studies revealed that the N95 respirators provide around 8 to 12 times increased defense than surgical masks against particles that are of the size 0.04–1.3 μm [15], but few studies reported that in case of low viral concentrations, both surgical and N95 masks are providing equal shielding against infections caused by flu. In US FDA, surgical masks have consent for sale; but in order to sell surgical masks in the UK, it has to first pass through the Medical Devices Directive (MMD 93/42/EEC) and be CE marked. In certain case of pandemics that involves aerosol transmission like what the world is experiencing now, there is a hike in shortages of N95/FFP2 respirators in some countries, so it is a piece of healthy information to be aware of the importance of surgical face masks in such circumstances [15].

European Standard Mask

The PN-EN 149:2001 standard for half masks is elucidated by 3 classes of protection. Filtering Face Piece 1 (FFP1) has a maximum internal leakage limit of 25% and retains 80% of particles that are smaller than 2 μm , Filtering Face Piece 2 (FFP2) has 11% maximum internal leakage limit and its retention capacity is 94% which can confine smaller particles of about 0.5 μm , and the filtering facepiece 3 (FFP3) has 5%

of maximum internal leakage limit and utmost retention percentage of about 99.95% which shut in smaller particles that are around 0.5 μm are retained [16].

US Standard Mask

N95, N99, N100 are single-use respirators, have filtration material that is made of an electrostatic non-woven polypropylene fiber that has supreme efficiency to restrict the entry of 0.3 microns sized microorganisms into the nasal or oral cavity. The N in these types of respirators signifies the presence of the non-oil particulate while those with the letter R indicate resistance to oil and the letter P stand for oil proof. The numerical values adjacent to the letters represent the efficiency of that particular respirator. The respirators have a close fit to prevent the facial fit and are recommended for use in respiratory disease. Hardly the drawbacks in using these respirators are that they are costly, not reusable, uncomfortable to wear, make difficulties while breathing. Nowadays the respirators come with valves that reduce the exhalation resistance and make breathing easier [14]. Studies have revealed to advocate the usage of respirators to reduce microorganisms that are airborne while

they can be easily penetrated in the surgical masks and enter the nasal or oral cavity [13]. Tight-fit respirators like N95 respirators and FFPs have higher efficiency to filter, Coffey et al. found that subjects failing a fit test also received adequate protection, resulting in high alpha errors [17].

Nanotechnology in facemask

Implementation of Nanotechnology-based products enables the development of new and improved products in face masks as they can act as a skillful barrier having a beneficial effect on the infiltration of dust and foreign particles (bacteria or viruses) at the very external layer. The schematic diagram of preparation of nanoparticles impregnated facemasks is shown in figure 1. Li et al. have studied the effect of silver nitrate and titanium dioxide-based nanoparticle that was coated on a surgical facemask, it was able to effectively inhibit the *Escherichia coli* (1/128) and *Staphylococcus aureus* (1/512). The antibacterial activity of the mask was quantified using AATCC 100-1999 and evaluated for skin irritation with volunteers, results in no skin irritation were reported [18].

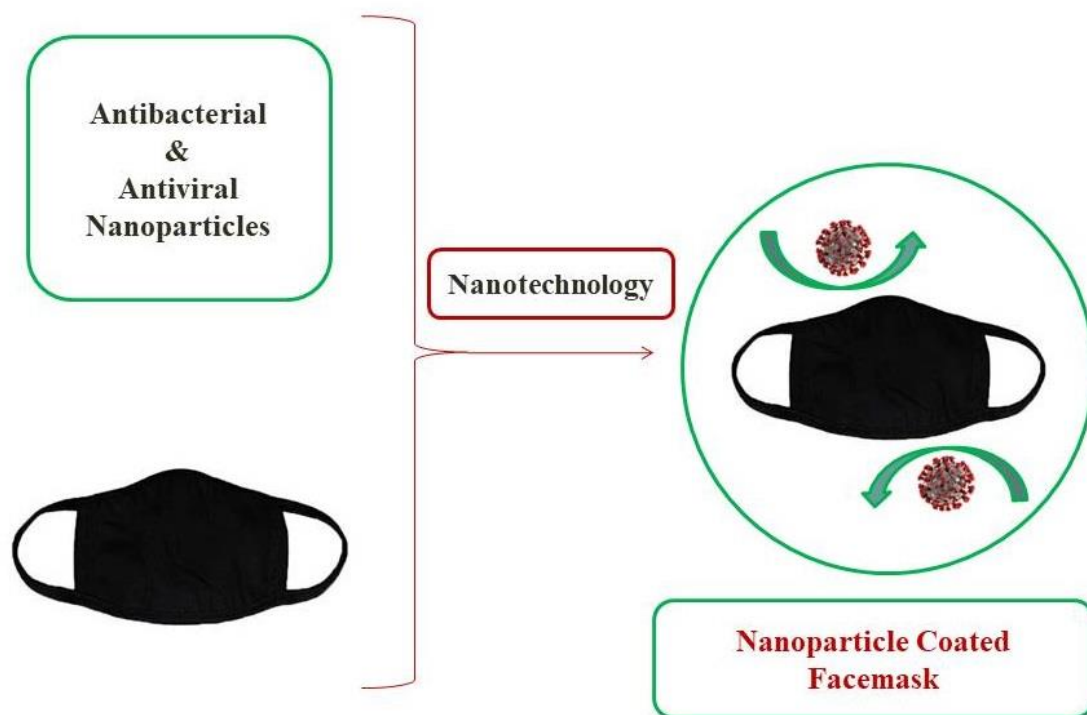


Figure 1. Schematic diagram of preparation of nanoparticles impregnated facemasks

Khamis-aloufy et al. proposed a nanosilver coated nanofibrous facemask. The electrospun Nylon 6 nanofibers produced by

electrospinning 24% of polymer content. The silver nanoparticle showed an effectual antibacterial response and higher efficiency [19].

Shehu et al. scrutinized the effect of silver nanoparticle coated facemask and reported high antiviral and antibacterial effects [20]. A nanofiber membrane prepared by electrospinning method using ZnO, Polyacrylonitrile, and Dimethylformamide is coated with lyocell spun lace non-woven with 40 GSM. Bacterial filtration efficiency test and air permeability test were performed in a laboratory which shows effective results of 99% and 77.5 cubic meters respectively [21]. The preparation of masks from certain non-degradable materials contributes to environmental pollution upon disposal after usage. Hence some degradable materials like biopolymer-based wheat gluten, a by-product of the cereal industries that can be utilized to produce nano-fibrous membrane when electrospun is done and could be further carbonized to get a network structure when treated at 700°C. These materials might have dual benefits, acting as an effective source of the filter and as a boon for the generation of gluten-based masks [22-24].

Conclusions

The study gives a comprehensible conjecture on what type of masks are an aid in the primary baseline prevention of the aerosol transmission affecting the respiratory system. It is deduced that the respirators are the high-end choice when it comes to basic prevention, by not letting the microbial particles into the nasal or oral cavity, but when the course of action whirl around the killing of the trapped microbial agents, mask nanotechnology-based masks might prove a better medicament and can abruptly cut down the risk of aerosol transmission. Cotton based homemade masks owing to their larger pore size might pave way for the entry of microorganisms like bacteria and virus, but these types of masks are easily affordable in a developing country, so in such cases when affordability comes into the picture, these masks can be used in combination with frequent sanitization and social distancing. Surgical masks come in the second stage that can prevent the entry of larger water particles, spills, aerosol particles but they cannot prevent the entry of viral particles, also their loose-fitting and easy wear and tear property will make them unfit for use. It is also advisable to use it along with frequent sanitization and social distancing. N95 and other such respirators overcome the

above problems and aid in the proper fitting of the mask to the face. They may prevent or trap the microbial agents but, cannot kill the viral or bacterial particles. To overcome all these features, the usage of nano-based masks are preferred as the nanoparticle coated masks comes with a pore size smaller than all the above-mentioned masks enables to trap the microbial particles, the nanomaterial coating will aid in the destruction of the microbial particle thus cuts down the adverse nasal or oral transmission of the microbial loads in case of a pandemic situation like this they might be an effective way of preventing community transmission

Conflict of interest

Authors declare there are no conflicts of interest.

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