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COVID-19: UV SANITIZER KIT FOR REUSABLE N95 MEDICAL MASK USING HYDROGEN PEROXIDE VAPORIZATION

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Abstract: The novel corona virus (SARS-CoV-2) is infecting people and spreading easily from person-to-person. Cases have been detected in most countries worldwide. Italy is one of the greatest exaggerated nations as of 30 March 2020. Public health response includes a rapid reorganization of the Italian National Healthcare System in order to reduce transmission of COVID-19 within hospitals and healthcare facilities, while optimizing the assistance to patients with severe COVID-19 complications. Kids are as likely as adults to become ill with SARS-CoV-2 after close contact with an infected person, according to a study of people in Shenzhen, China. According to guidelines of WHO there are various precaution measures to prevent us from the COVID-19. Face masks have become a symbol in the fight against the violent coronavirus.N95 and remedial masks, which offer the best safety and are seriously in demand, should be reserved for health care workers who are regularly exposed to infected patients. In this journal, we obtained the UV Sanitizer kit using Ultraviolet germicidal irradiation (UVGI) to make the N95 mask reusable. Apply proper heat and UV light with certain time to reuse and Clean the N95 mask can be re-use up to 3 times. The above process is achieved by the Hydrogen Peroxide Vaporization. To achieve this we use the control chamber RD150 with chamber size Chamber size - 40cm X 40cm X 40cm. Control card had a buzzer which make sound once the time reach 30 Minutes Door Open sensor will ensure the Chamber door is closed during the cleaning process. Control unit will display the current Temperature, Humidity and Time.

Keywords: COVID-19; N95 mask; UV Sanitizer kit; Hydrogen Peroxide Vaporization;

I. INTRODUCTION

Mankind has observed various pandemics throughout the history where some of the were more disastrous than the others to the humans. We are observing a very tough time once again fighting an invisible enemy; the novel COVID-19 coronavirus. Initially observed in the Wuhan province of China, now fastly spreading around the world.As of today, 20th March, 2020, there are 270,069 Coronavirus cases, with 11,271 deaths while 90,603 has been recovered. In the total Coronavirus patients died, very interestingly the highest number belongs to Italy i.e. 4,032 deaths. The death toll is followed by China (3,248), Iran (1,433) and Spain (1,044) [11, 18]. COVID-19, also known as coronavirus disease or novel coronavirus, is caused by a type of virus that causes respiratory illness. This may lead to inflammation and the build-up of mucus and fluids in the airway of the lungs (pneumonia). There are many different coronaviruses.

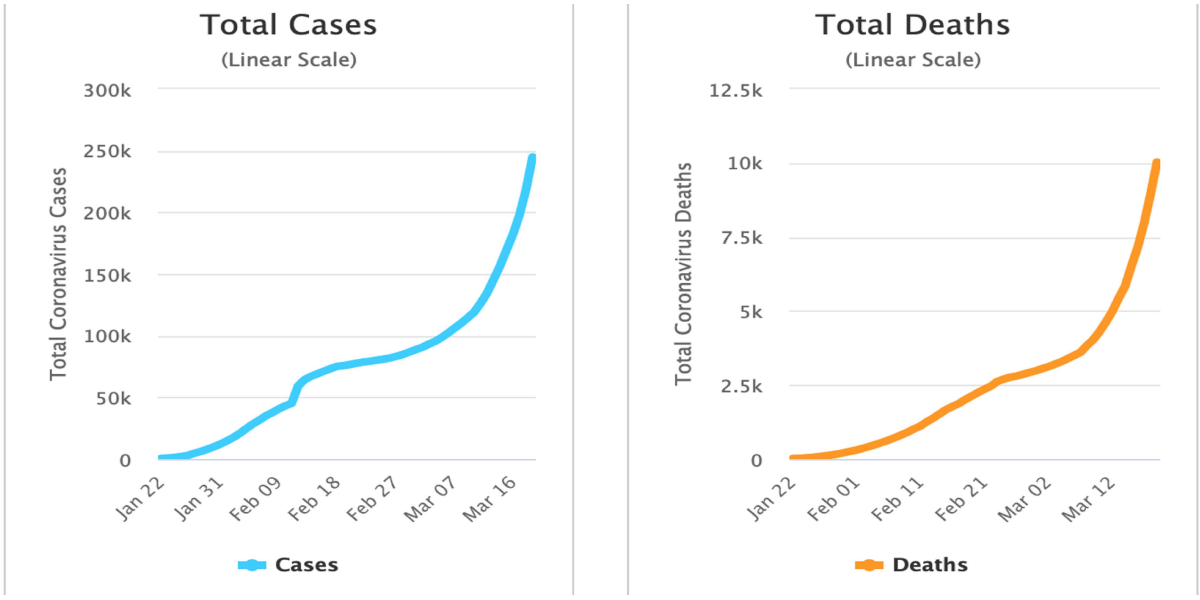

Fig. 1 The rise of deaths and active cases of Coronavirus

Most of these viruses only affect animals, but sometimes these viruses can change and infect people. This illness is caused by a virus. You may catch the virus by Breathing in droplets from an infected person's cough or sneeze. Touching something, like a table or a doorknob, that was exposed to the virus (contaminated) and then touching your mouth, nose, or eyes. Being around animals that carry the virus, or eating uncooked or undercooked meat or animal products that contain the virus. COVID-19 causes respiratory illness that can lead to pneumonia. Symptoms of pneumonia may include: a fever, a cough. Difficulty breathing. There is no medicine to treat COVID-19. Your health care provider will talk with you about ways to treat your symptoms. This may include rest, fluids, and over-the-counter medicines.

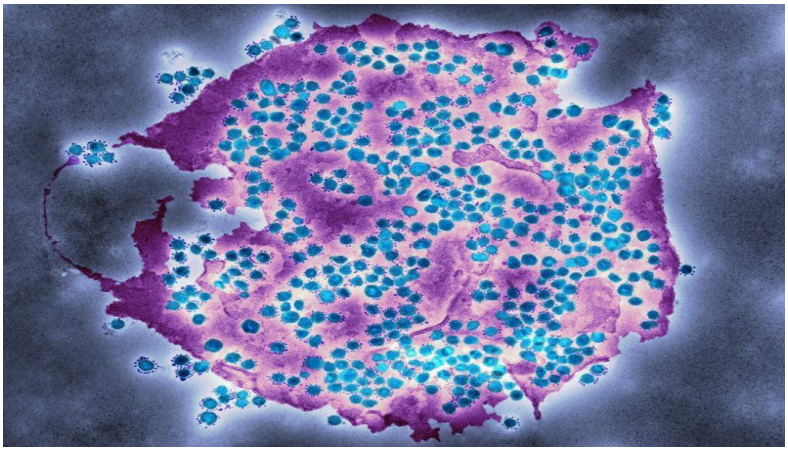

Fig. 2 Pathological image of COVID-19 march 2020

A. How we prevent from COVID-19

There is no vaccine to help prevent COVID-19 infection. However, there are steps you can take to protect yourself and others from this virus.

B. To protect yourself

- Do not travel to areas where COVID-19 is a risk. The areas where COVID-19 is reported change often. To identify high-risk areas, check the CDC travel website: wwwnc.cdc.gov/travel/notices
- If you live in, or must travel to, an area where COVID-19 is a risk, take precautions to avoid infection.
- Stay away from people who are sick.
- Stay away from places where there are animals that may carry the virus. This includes places where animals and animal products are sold. Note that both living and dead animals can carry the virus.
- Wash your hands often with soap and water. If soap and water are not available, use an alcohol-based hand sanitizer.
- Avoid touching your mouth, face, eyes, or nose.

C. To protect others

If you have symptoms, take steps to prevent the virus from spreading to others.

- If you think you have a COVID-19 infection, contact your health care provider right away. Tell your health care team that you think you may have a COVID-19 infection.
- Stay home. Leave your house only to seek medical care.
- Do not travel while you are sick.
- Wash your hands often with soap and water. If soap and water are not available, use alcohol-based hand sanitizer.
- Stay away from other members of your household. If possible, stay in your own room, separate from others. Use a different bathroom.
- Make sure that all people in your household wash their hands well and often.
- Cough or sneeze into a tissue or your sleeve or elbow. Do not cough or sneeze into your hand or into the air.
- Wear a face mask.

II. RELATED WORK

Coronavirus disease (COVID-19) is an infectious disease caused by a newly discovered coronavirus. Coronaviruses are the well-known cause of severe respiratory, enteric and systemic infections in a wide range of hosts including man, mammals, fish, and avian. The scientific interest on coronaviruses increased after the emergence of Severe Acute Respiratory Syndrome coronavirus (SARS-CoV) outbreaks in 2002-2003 followed by Middle East Respiratory Syndrome CoV (MERS-CoV). This decade's first CoV, named 2019-nCoV, emerged from Wuhan, China, and declared as 'Public Health Emergency of International Concern' on January 30th, 2020 [14,7] by the World Health Organization (WHO). As on February 4, 2020, 425 deaths reported in China only and one death outside China (Philippines). In a short span of time, the virus spread has been noted in 24 countries. WHO published the first Strategic Response and Preparedness Plan on 3 February 2020. As on April 2020 [15], huge amount about COVID-19 deaths reported all over the world and how best to slow and stop it spreading through communities around the world.

WHO has been rapidly translating this new knowledge into guidance for national governments, health workers, and everyone else involved in the global response to COVID-19. On 14 April 2020, WHO published a strategy update reflecting what we have learnt to inform the next iteration of the Strategic Preparedness and Response Plan (SPRP) due in the coming weeks. The successful virus isolation attempts have made doors open for developing better diagnostics and effective vaccines helping in combating the spread of the virus to newer areas [4,9].

Coronaviruses (CoVs) are well-known causes of severe infections, respiratory, enteric and systemic, in humans and numerous animal hosts. The CoV infections have been reported in cattle, swine, horses, camels, rodents, cats, dogs, bats, palm civets, ferrets, mink, rabbits, snake, and several other wild animals and avian species [16]. Though human CoVs were identified for the first time in the year 1960 from respiratory infections in adults as well as children, the major scientific interest in CoVs research grew only after the emergence of Severe Acute Respiratory Syndrome CoV (SARS-CoV) in the year 2002-2003 [13]. In this SARS-CoV epidemic, around8000 confirmed human cases with 774 deaths (around 9.5% mortality rate) occurred that was a result of its global spread [12]. Initially, the virus was detected in the caged Himalayan palm civets and these were thought to be the natural host of this virus [5]. Following SARS-CoV incidence in 2003, a similar CoV named HKU3-1 to HKU3-3 were identified in the horseshoe bats (non-caged) in 2005 from Hong Kong [17]. Since then, bats [3,8] are considered to be the natural host and potential reservoir species that could be held responsible for any future CoVs epidemics and/or pandemics [2].

After the 2003 and 2005 SARS-CoV epidemics, an analogous virus emerged in the Middle East region of the world leading to severe respiratory illness and was named the Middle East Respiratory Syndrome CoV (MERS-CoV) [19]. The mortality was higher than previous SARS-CoV pandemic claiming around 919 lives out of the total 2521 human cases (around 35% mortality) (World Health Organization 2015). Notably, dromedary camels were connected with the transmission of MERS-CoV [1]. Further, its origin was also traced from bats. All these highly pathogenic human CoVs, SARS and MERS, show emergence over wider areas of the world posing high risk of human-to-human transmission and fatal consequences thereto.

III. N95 MASK

N95 respirators and surgical masks (face masks) are examples of personal protective equipment that are used to protect the wearer from airborne particles and from liquid contaminating the face. Centres for Disease Control and Prevention (CDC) National Institute for Occupational Safety and Health (NIOSH) and Occupational Safety and Health Administration (OSHA) also regulate N95 respirators.

Fig. 3 N95 respirators for COVID-19

A. N95 Respirators Not for Use by the General Public

The Centres for Disease Control and Prevention (CDC) does not recommend that the general public wear N95 respirators to protect themselves from respiratory diseases, including coronavirus (COVID-19). Those are critical supplies that must continue to be reserved for health care workers and other medical first responders, as recommended by current CDC guidance.

B. CDC Recommends Cloth Face Coverings for Use by the General Public

The CDC recommends that members of the public use simple cloth face coverings when in a public setting to slow the spread of the virus, since this will help people who may have the virus and do not know it from transmitting it to others. For more information, see the CDC's Transmission. The best way to prevent illness is to avoid being exposed to this virus. However, as a reminder, the CDC always recommends everyday preventive actions, such as hand washing and maintaining at least 6 feet of social distancing, to help prevent the spread of respiratory diseases.

C. Comparing Surgical Masks and Surgical N95 Respirators

The FDA regulates surgical masks and surgical N95 respirators differently based on their intended use.

- A surgical mask is a loose-fitting, disposable device that creates a physical barrier between the mouth and nose of the wearer and potential contaminants in the immediate environment. These are often referred to as face masks, although not all face masks are regulated as surgical masks. Note that the edges of the mask are not designed to form a seal around the nose and mouth.
- An N95 respirator is a respiratory protective device designed to achieve a very close facial fit and very efficient filtration of airborne particles. Note that the edges of the respirator are designed to form a seal around the nose and mouth. Surgical N95 Respirators are commonly used in healthcare settings and are a subset of N95 Filtering Face piece Respirators (FFRs), often referred to as N95s.

The similarities among surgical masks and surgical N95s are:

- They are tested for fluid resistance, filtration efficiency (particulate filtration efficiency and bacterial filtration efficiency), flammability and biocompatibility.
- They should not be shared or reused.

D. General N95 Respirator Precautions

All FDA-cleared N95 respirators are labeled as "single-use," disposable devices. If your respirator is damaged or soiled, or if breathing becomes difficult, you should remove the respirator, discard it properly, and replace it with a new one. To safely discard your N95 respirator, place it in a plastic bag and put it in the trash. Wash your hands after handling the used respirator.

IV. PERSONAL SANITIZATION USING ULTRAVIOLET GERMICIDAL IRRADIATION (UVGI)

Ultraviolet germicidal irradiation (UVGI) is a disinfection method that uses short-Wave length Ultraviolet (ultraviolet C or UVC), light to kill or inactivate microorganisms by destroying nucleic acids and disrupting their DNA, leaving them unable to perform vital cellular functions. UVGI is used in a variety of applications, such as food, air, and water purification. UVC light is weak at the Earth's surface as the ozone layer of the atmosphere blocks it. UVGI devices can produce strong enough UVC light in circulating air or water systems to make them inhospitable environments to microorganisms such as bacteria, viruses, molds and other pathogens. UVGI can be coupled with a filtration system to sanitize air and water. The application of UVGI to disinfection has been an accepted practice since the mid-20th century. It has been used primarily in medical sanitation and sterile work facilities. Increasingly, it has been employed to sterilize drinking and wastewater, as the holding facilities are enclosed and can be circulated to ensure a higher exposure to the UV. In recent years UVGI has found renewed application in air purifiers. UV light is electromagnetic radiation with wavelengths shorter than visible light but longer than X-rays. UV can be separated into various ranges, with short-wavelength UV (UVC) considered "germicidal UV". Wavelengths between about 200 nm and 300 nm are strongly absorbed by nucleic acids. The absorbed energy can result in defects including pyrimidine dimers. These dimers can prevent replication or can prevent the expression of necessary proteins, resulting in the death or inactivation of the organism.

- Mercury-based lamps operating at low vapour pressure emit UV light at the 253.7 nm line.
- Ultraviolet light-emitting diodes (UVC LED) lamps emit UV light at selectable wavelengths between 255 and 280 nm.
- Pulsed-xenon lamps emit UV light across the entire UV spectrum with a peak emission near 230 nm.

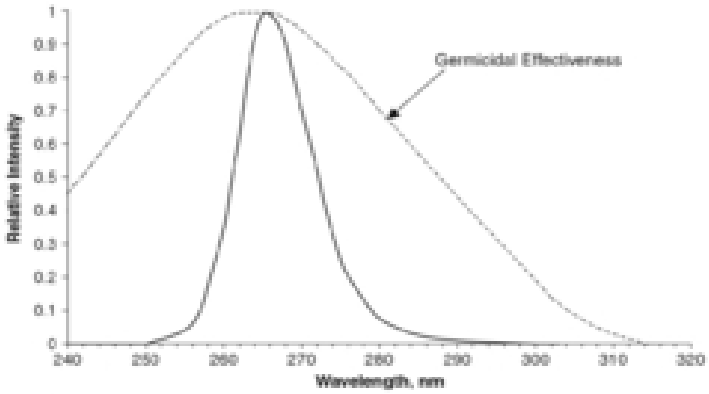

Fig. 4 wavelength curve for UV light Emitting Diodes

UVC LED emitting 265 nm compared to E.coli germicidal effectiveness curve. This process is similar to the effect of longer wavelengths (UVB) producing sunburn in humans. Microorganisms have less protection against UV, and cannot survive prolonged exposure to it.A UVGI system is designed to expose environments such as water tanks, sealed rooms and forced air systems to germicidal UV. Exposure comes from germicidal lamps that emit germicidal UV at the correct wavelength, thus irradiating the environment. The forced flow of air or water through this environment ensures exposure.

IV. N95 MASK REUSE PROCESS

N95 mask which can remove 95% of 0.3micron particles in the non-oil based air and the material for the mask is an electrostatic non-woven polypropylene fibre. Apply proper heat and UV light with certain time to reuse/Clean the N95 used mask. Though this process one mask can be re-use up to 3 times.

A. Heat Process: For optimal results, a heating protocol should both completely inactivate viral particles on the mask, and preserve the filtration efficacy of the mask. Heating of the mask at 70C for 30 minutes has been suggested as a method of decontamination which adequately preserves the filter integrity for re-use. Also keep the humidity less than 40% inside the heat chamber.

B. UV treatment: Proper UV treatment of N95 masks requires specific dosing protocols and full surface area illumination to ensure proper inactivation of viral particles with minimal mask degradation for 30minints. Due to the precision required, home UV light use is not recommended. There are two factors that directly influence the effectiveness of UV-C disinfection: time of exposure and light intensity. The amount of time UV-C is exposed to any given pathogen is proportional to the amount of killing it does. Used N95 mask exposed to high-dose UVGI irradiated with a 254 nm UV lamp at 1.8 J/cm2.

C. Hydrogen Peroxide Vaporization: After above process 1 & 2 apply Hydrogen Peroxide-vaporization.

V. CLEANING CHAMBER DETAILS

Fig. 5 Proposed UV chamber for N95 mask

We develop a special chamber with the following features. Used mask hangs the masks on a fishing line inside the UV chamber. Please note that place only one used N95 Mask inside the chamber for cleaning.

The Components we carried inside the chamber to carry out the process:

1. Chamber has 2 high-dose UVGI irradiated with a 254 nm UV lamp, one on the top side and one on the bottom side of the chamber.

Fig. 6 UVGI 254 nano meter

2. Chamber has a 200W coil type heater to maintain the temperature up to 65 +/- 1 degree. Fixed a small Fan behind the Heater to circulate the heat inside the chamber.

Fig. 7 200W coil type

3. Chamber control unit –

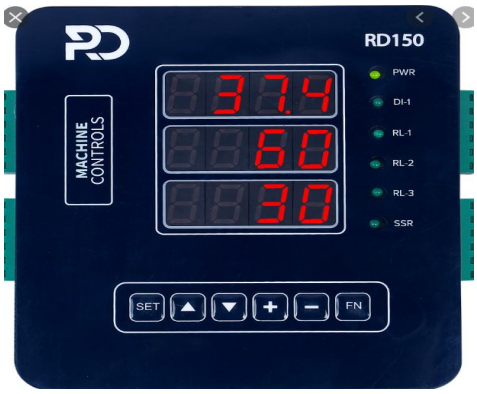

Fig. 8 Control unit RD150

a. Control unit has the following sensors. Mask detection sensor, Door open sensor, Temperature sensor, Humidity sensor and UV intensity sensors.
b. Control unit controls the temperature inside the chamber 65 +/- 1 degree. After 30 minutes the heater will OFF automatically if the mask is not removed.
c. Control unit controls the UV light intensity by adjusting the voltage. Also using a UV sensor to ensure the exposed UV intensity to the mask .After 30 minutes the UV light will OFF automatically if the mask is not removed.
d. Control card had a buzzer which make sound once the time reach 30 Minutes
e. Door Open sensor will ensure the Chamber door is closed during the cleaning process.
f. Control unit will display the current Temperature, Humidity and Time.

4. Chamber material and Size -

a. Preferred stainless steel material to the inside of the chamber. Also the inside of the chamber should reflect the UV light to improve the Mask cleaning process.
b. Chamber size - 40cm X 40cm X 40cm.

VI. CONCLUSIONS

All FDA-cleared N95 respirators are labelled as "single-use," disposable devices. If your respirator is damaged or soiled, or if breathing becomes difficult, you should remove the respirator, discard it properly, and replace it with a new one. To safely discard your N95 respirator, place it. In our UV Sanitizer kit using Ultraviolet germicidal irradiation (UVGI) to make the N95 mask reusable. Apply proper heat and UV light with certain time to reuse and Clean the N95 mask can be re-use up to 3 times. The above process is achieved by the Hydrogen Peroxide Vaporization. To achieve this we use the control chamber RD150 with chamber size Chamber size - 40cm X 40cm X 40cm. Control card had a buzzer which make sound once the time reach 30 Minutes Door Open sensor will ensure the Chamber door is closed during the cleaning process. Control unit will display the current Temperature, Humidity and Time.

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