An Assessment Of The AFL Mask® And LUNA Wallmount, The New Developments In The Air-Purifier Industry For Preventing The Airborne Pathogens

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Abstract

The current unprecedented situation with the COVID-19 (Coronavirus Disease 2019) poses a great challenge to the scientific world, demanding immediate development of technologies to fight with and prevent transmission of pathogens, especially in regards to airborne pathogens and surface contaminants. It also urges us to reevaluate designs of advanced Personal Protective Equipment (PPE). We have been working on the development and assessment of the AFL-Photo Catalytic Oxidation (AFLPCO®) Nanotechnology to combat with airborne pathogens and different forms of impurities and pollutants present in the indoor air. Various types of facemasks are available in the world market and have become the most important personal protective equipment for healthcare workers and the public. Depending upon their filters, they can provide protection against dreaded contagious diseases and several types of pollution. With the current

spread of the COVID-19 Pandemic, facemasks and powerful air purification equipment are considered as lifesaving apparatus necessary for survival and living a healthy life. The facemasks filter fine airborne particles from reaching the respiratory system and prevent infection. We have designed a new type of facemask, AFL Mask® and LUNA Wall Mount Sanifier® air purification unit to combat with the airborne pathogen and increased air pollution. The AFL Mask® has proven to prevent the entry of the $PM_{2.5}$ and airborne pathogen up to 99% and provide internal air, reducing the chances of building up moisture on the face. This newly designed AFL Mask® and LUNA Wall Mount Sanifier® can be used to prevent the pathogens and particulate matters significantly. We also tested the LUNA Wall Mount Sanifier® (LNT2-6000 Model), AFL Car Sanifier® and AFL Mask® for Ozone emission. All the equipment tested were proven safe to international standards in terms of Ozone emission.

Keywords: AFL Mask®, COVID-19 Pandemic, Air purification, Aerosol, AFLPCO®, PM

Introduction

The current unprecedented situation with the COVID-19 (Coronavirus Disease 2019) has shown us that the scientific world still needs more efforts to meet the upcoming challenges: to prevent, protect, and cure dreaded diseases. Personal Protective Equipment (PPE) play a key role in preventing the spread of diseases and protecting the health of the individual. To introduce technology in these PPE can make their use more convenient and effective to the masses. Nanotechnology promises significant improvements of advanced materials and manufacturing techniques, which are critical for the future competitiveness of national industries[1]. We have been working on the development and assessment of the AFL Photo Catalytic Oxidation (AFLPCO®) Nanotechnology to combat with airborne pathogens and various forms of impurities and pollutants present in the air. New world trade and economy are based on the application of innovative technology developing novel products that are in great demand. Global economies are so tightly interconnected that companies, governments and industries will soon be forced to cooperate in ways we could not have imagined just a few years ago. Innovations in technology continue to have massive effects on business and society. We are now seeing emerging markets become hotbeds of innovation, especially in efforts to reach the growing middle class and low-income consumers around the globe. This report covers the information on how a Nanotechnology research product was developed and marketed in many countries.

Collaboration between the corporate worlds with academia has proven beneficial in scientific inventions. With the increased population growth and industrial expansions, most cities are experiencing poor air quality. We have been working on the development and assessment of the AFL Photo Catalytic Oxidation (AFLPCO®) Nanotechnology to combat airborne pathogens and different forms of impurities and pollutants present in the indoor air. New world trade and economies are based on the application of innovative technology, developing novel products that are in great demand. We are in the need of a much advanced air purifier that works on airborne pathogens and improves the air quality with a greater extent than the existing air purifiers on the market.

Fig. 1. Different types of masks in use. 1A. Cloth mask. 1B surgical masks. 1C. N95 and professional grade medical masks. 1D. Sponge mask

In the context of the COVID-19 pandemic, wearing a facemask has become usual and ubiquitous, in both hospitals and community. However, the public is consuming surgical or filtering face piece (FFP) masks irrespective of their specificity, leading to a global supply shortage for the most exposed persons, the healthcare workers. This underlines the urgent need to clarify the indications of the different categories of mask in order to rationalize their use2. Various types of facemasks are available in the world market (Fig.1A-D). Facemasks are the most important personal protective equipment (PPE) for healthcare workers and the public. Depending upon their filters, they can provide protection against dreaded contagious diseases and severe pollution. They filter fine airborne particles from reaching the respiratory system and prevent infection. There are some studies, which show

the relation between air pollution and increasing heart rate and blood pressure[3], and how wearing the facemask can help maintain heathy blood pressure and heart rates in susceptible people. However, wearing a mask may be harmful to some people with heart or lung disease because it can make the lungs work harder to breathe. Some masks like N95 give exhaled moisture breathing resistance if worn for more than four hours[4]. Wearing masks could affect the wearer's whole-body thermal sensation. Long duration wearing of N95 respirators may induce physiological stress on the wearer. Healthcare providers may develop headaches following the use of the N95 facemask. Shorter duration of facemask use may reduce the frequency and severity of these headaches[5, 6].

In the present context, we report the development of a novel facemask by the AFL Industries in the UK, which was assessed for the safety measures and further improvement by West Texas A&M University. This mask involves an exceptional 4-staged filtration system to combat all forms of airborne pathogens including bacteria, viruses, mold spores and harmful VOCs (Volatile Organic Compounds) present in the air. The major drawbacks of the other masks available in the market are: i) the mask-users feel suffocated due to the lack of any internal air supply, ii) most of the cheap cloth-made masks are incapable of filtering the smaller particulate matters and VOCs, ii) long-term use of those masks results in condensation and deposition of condensed moisture in the nose area allowing pathogens to build-up and result in infections.

Methods and Operation

A collaborative effort of research and assessment between Air For Life (UK) and West Texas A&M University developed a newly designed mask, the AFL mask, aimed to provide a solution to these problems. These masks are easy to use and ergonomically designed for maximum comfort. It contains an electric fan for a continuous fresh airflow within the mask. The air supply system has a constant positive pressure to allow easy breathing without a suffocating feeling. The unique design of the air vent prevents the buildup of condensation inside. The fan is smooth functioning with low noise, and works using a rechargeable polymer lithium-ion battery with a long working life.

The AFL Mask uses a one-touch control, offering two fan speeds. One press of the button starts the fan, a second press increases the speed and a third press of the button shuts off the fan (Fig. 2).

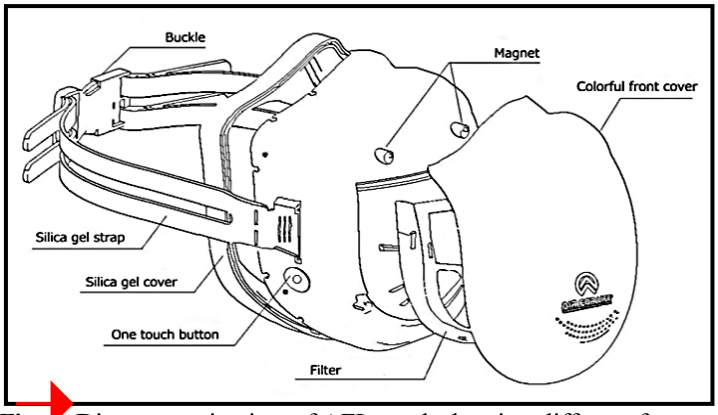
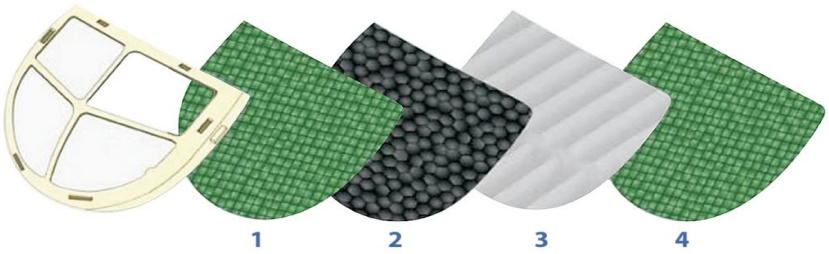


Fig. 2. Diagrammatic view of AFL mask showing different features

AFL Masks: Filters

AFL mask contains filters which consist of high-efficiency four-stage nano silver ion filters for maximum protection against 99.9% of all indoor and outdoor impurities such as: bacteria, dust, pollen, mites, viruses, pet dander, $PM_{2.5}$, smoke, formaldehyde, benzene and other gaseous pollutants, and Volatile Organic Compounds (VOCs). Wearing the Air for Life Mask can eliminate the potential health risk caused by air pollution and airborne diseases. Many articles have drawn the attention of the scientific community towards the elevated risks of airborne transmission of diseases and the associated risks of epidemics or pandemics. The complexity of the problem and the need for multidisciplinary research is highlighted. The airborne route of transmission, i.e. the generation of pathogen-laden droplets originating in the respiratory tract of an infected individual, the survivability of the pathogens, their dispersal indoors and their transfer to a healthy person are recently reviewed[6].

Fig. 3. Four-stage filter system



1. The first stage (layer 1 and 4) is the primary antibacterial cotton filter that blocks dust and larger particles.

2. The second stage is an efficient, activated carbon filter that prevents inhalation of bad odors and harmful gases.
3. The third stage is an antibacterial nano silver ion layer sprayed on the fourth stage HEPA layer. The nano silver ions effectively protect against harmful bacteria, such as *Escherichia coli*
Staphylococcus aureus, etc., and viruses (Fig. 3).
4. The fourth stage is the highly efficient HEPA filter that uses 3M's H11 Filtrete® filter to remove particles effectively up to 0.3 microns. $PM_{2.5}$ filtration efficiency is evaluated to be more than 99%.

AFL Masks: Belt

As seen in the pandemic of COVID-19, apart from the shortage of PPE, healthcare professionals are facing another problem of keeping masks on continuously. Most of the masks available in the market have elastic strings with the ear loop style. This creates pain on the external ear or pressure injury on the ears' skin[7]. AFL masks offer a practical solution to this problem using adjustable belts (Fig. 4), which goes above and below the ears and connect at the backside of the head, minimizing ear discomfort.

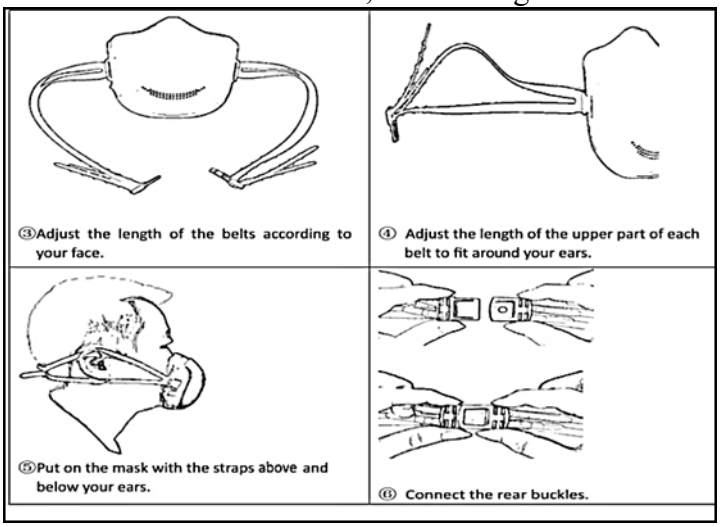


Fig. 4 Steps to put on the AFL Mask

AFL Masks: Care and Filter Replacement

AFL masks come with replaceable filters. The permanent part of the masks can be cleaned and maintained as followed:

1. Surface cleaning: Any alcohol-based solution can be used to wipe the surface.
2. Silicone gel cover cleaning: Silica gel cover is to be removed and washed with an alcohol solution. It can also be sterilized in boiling

water for five minutes. After cooling and drying, it can be re-attached to the front of the mask.

3. The internal parts of the mask are not waterproof, so cleaning with water is not recommended.

Filter replacing steps

Effortlessly, the filter can be changed with one button for easy operation. The frequency to change the filters depends on the environmental conditions. In a lightly polluted environment, change the filter every 2-3 months; in a non-tolerable highly polluted environment, change it every 1-2 weeks. The steps to follow:

1. Remove the magnetic front cover of the mask.
2. Replace the old filter with a new one.
3. Re-attach the magnetic front cover of the mask.

Fig. 5. Replaceable filters for the AFL Masks available in market.

Disinfecting the mask

As the world is facing the scarcity of masks, reusing the disinfected mask can save many lives. AFL Masks come with the added advantage that its outer part can be easily sterilized and the filters can be replaced (Fig. 5) as recommended. In the case of a pandemic creating high demand, disinfecting the filter may be a more suitable option. The AFL Masks can be disinfected by Ozone gas treatment, Autoclaving, Vaporous hydrogen peroxide procedure, Per-acetic acid dry fogging system, Ethylene oxide gas and by a low temperature hydrogen peroxide gas plasma treatment well.

Evaluating efficacy of mask protection against fungal spores, bacteria, and $PM_{2.5}$

The AFL mask is fitted around a dummy head (SKU: 10-142 Simulaids® Transport Head, WorldPoint). The head is then

inserted halfway up to the ears into a fiberglass chamber (C-1, Fig. 6) wall, where it fits without leakage. The other portion of the head is in the other sterilized chamber (C-2) where we evaluate air quality using an air quality monitor and keep the sterilized media plated Petri plates. Petri plates with microbial colonies (marked with arrows in Fig. 6) are kept in chamber-1 (C-1). The concentration of spores are noted; consequent monitoring of the growth and number of fungal/bacterial colonies formed in chamber-2 at different time intervals are documented. If the mask permits any spore, the fungal colony will develop in the sterilized chamber. A corresponding experiment was conducted for $PM_{2.5}$ with a similar set up. This experimental procedure has evaluated the efficacy of the mask.

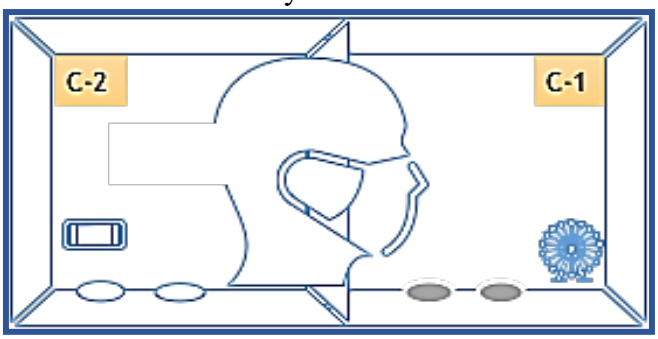


Fig. 6. Experimental setup of two glass chambers. C-1 with fan for equal air circulation and Petri plates with fungal colonies. C-2 with media containing Petri plates and air quality monitor.

AFLPCO® Technology

Allergens such as dust, smoke, pollen and animal dander are airborne particles that can cause allergy symptoms, allergic rhinitis, asthma, and COPD exacerbation in susceptible individuals. Allergy symptoms arise in areas that are in contact with the air, such as the eyes, throat, nose, and lungs, and causes allergic rhinitis, allergic sinusitis, allergic conjunctivitis, sneezing, coughing, wheezing, and shortness of breath. An estimated 300 million people worldwide suffer from asthma, with 250,000 annual deaths attributed to the disease. About 70% of asthmatics also have allergies[8]. It is estimated that the number of people with asthma will grow by more than 100 million by 2025.

Workplace conditions, such as exposure to fumes, gases or dust, are responsible for 11% of asthma cases worldwide. Almost all of the premature deaths from asthmatic symptoms are avoidable by taking proper safety measures and wearing the PPEs. Occupational asthma contributes significantly to the global burden of asthma, since the condition accounts for approximately 15% of asthma cases among adults. The Air For Life Photo Catalytic Oxidation (AFLPCO®) Technology reduces the incidence of asthma and its associated symptoms by destroying triggering aeroallergens such as household dust mites and their droppings, mold, pollen and fungal spores.

As AFLPCO® emits human friendly low doses of negative ions, the air as well as nearby objects and surfaces in the room are sterilized. This is particularly useful in dental surgeries and operating theaters as AFLPCO® can sterilize surgical tools and equipment, and combat the spread of infection from one patient to the next.

Photo Catalytic Oxidation or PCO technology began with NASA in 1994 to purify the air in spacecrafts. When NASA began planning for deep space exploration, including proposed manned missions to Mars such as the "Constellation Mission Program" in 2013, sustaining life in space for months and years at a time was necessary. Before preparing for deep space exploration, NASA had to find an answer to ethylene gas destroying plants and vegetables in the space shuttle. Ethylene gas is the naturally occurring hormone released by plants and vegetables to signal ripening. On earth, it is naturally dispersed into the atmosphere, but in a sealed spacecraft, ethylene build up becomes toxic, killing those very same plants and vegetables if not removed. Scientists at NASA developed a new green technology called Photo Catalytic Oxidation (PCO) to remove the ethylene gas build-up. PCO technology works by breaking down the ethylene gas into harmless Carbon Dioxide (CO_2) and Water (H_2O) by exposure to Ultra Violet (UV) light in the presence of a Titanium Dioxide (TiO_2) catalyst. Further tests by NASA revealed PCO technology not only eliminated ethylene gas build up, but also destroyed all carbon-based impurities in the air such as bad odores, Volatile Organic Compounds (VOC's), Fungi, Bacteria, and Viruses[9].

Our team of scientists has further enhanced the NASA developed PCO technology by creating the Air For Life Photocatalytic Oxidation (AFLPCO®). The LUNA Green AFLPCO® Cell™ is coated inside with the AFL Nano five metal catalyst and contains two high quality, long lasting AFL germicidal UVC bulbs. Photons of ultraviolet (UV) light react with the AFL nano five metal catalyst, which leads to the formation and release of millions of human friendly negative ions. This abundance of negative ions are released into the air by the machine with the Air For Life AFLPCO® catalyst and flood the room; they then collide and react with pathogens and allergens in the air and on surfaces, and destroy or demobilize them on contact.

Experimental set up in a fiberglass chamber (Figs. 6, 9A) to test the AFL Mask® in preventing microbial spores and $PM_{2.5}$

A Fiberglass chamber was divided into two chambers, C-1 and C-2, by placing a fiberglass wall in between. A slot was made to fit the AFL Mask® and sealed to make the chambers airtight. We placed Petri plates every 24 hours on both the C-1 and C-2 sides and counted the colonies formed while

keeping the mask running. The number of microbial colonies in the Petri plates on side C-1 (No filtered air) were compared with the C-2 (Filtered Air passed through the AFL Mask) (Fig. 6) Petri plates. Every 24h-interval showed variable counts of the microbial colonies (Fig. 7). In the next part of the experiment we compared the $PM_{2.5}$ count in both of the chambers, C-1 and C-2, after 24, 48, 72, 96, and 120 hours. In this experiment, we used dust consisting of Particulate Matters (PM) ranging 2.5-10 micrometers. We purchased the ISO 12103-1 Ultrafine Dust Particle with an average size of 2.75 micron (PTI Powder Tech., Minnesota) to evaluate particle concentration reduction. We have calculated the natural rate of decay of the Particulate Matters by placing a *Temtop M2000C* Air Quality Monitor in the chambers after aerosol saturation in 24-hour periods (Table-1). Using fans, we spread the $PM_{2.5}$ in the chamber (C-1) uniformly and waited for 72 hours to develop an equilibrium in the contained aerosol. All chamber doors and the slot where the AFL Mask was fitted were sealed air tight using silicone grease to ensure Particulate Matters did not disperse out of the chamber. We have recorded the number of $PM_{2.5}$ floating inside the chamber C-1 and C-2 by using a *Temtop M2000C* Air Quality Monitor.

Results and Discussion for Section 1

Table-1 shows the comparative $PM_{2.5}$ count after 24, 48, 72, 96 and 120 hours in chamber-1 and chamber-2.

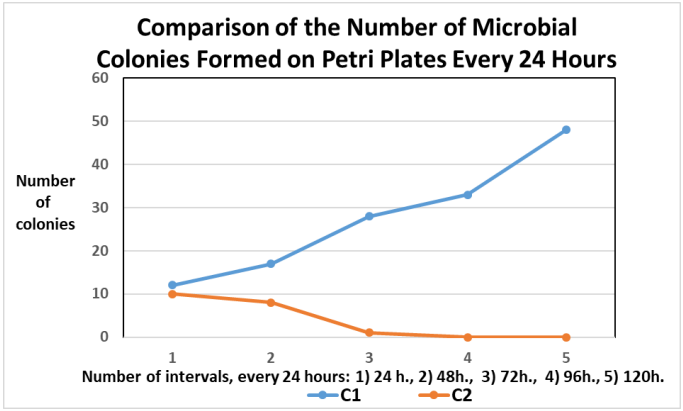


Fig. 7. A graph showing the number of microbial colonies in the Petri plates on the side C-1 (No filtered air) and on the side C-2 (Filtered Air passed through the AFL Mask, Fig.6). Petri Plates were changed every 24 hours. Every interval showed variable counts of microbial colonies.

	$PM_{2.5}$ count	**$PM_{2.5}$ count**
Interval of reading	**Chamber 1 (C1 with unfiltered air) Showing natural decay**	**Chamber 2 (C2) (In air filtered with AFL Mask)**
24h.	4817	1
48h.	3370	0
72h.	2815	0

96h.	1563	0
120h.	875	0

Table-1 showing the comparative $PM_{2.5}$ count after 24, 48, 72, 96 and 120 hours.

Chamber-1 (C-1) contains unfiltered air. It shows the rate of particulate count with natural decay. Chamber-2 (C-2) has air filtered with AFL Mask®. On using the AFL Mask®, no particle transmitted into chamber-2 from the chamber-1 indicating protection from Particulate Matters when the AFL Mask® is used. In the first 24-hour period in chamber-2, there were readings for the detected presence of 1-2 particles. We think they were likely present in the chamber when beginning the experiment.

LUNA Wallmount: AFL vs HEPA Filter

Almost 99% of all particles that we breathe into our lungs are under 1 micron[10]. Most HEPA filters can only filter particles in the air up to 0.3 microns. HEPA filters are commonly thought to be impenetrable to particulate matter, but in fact, they are only 99.97% efficient at collecting the most penetrating particle (~ 0.2 micrometer). While this is an impressive collection efficiency, HEPA filters may be vulnerable to certain types of threats; viruses are submicron in size and most have very small minimum infection doses (MID50). Therefore, an appropriate viral challenge will yield penetration that exceeds the MID for many of the threat agent viruses. This means most all viruses can easily pass through HEPA[50] filters, as they all are usually smaller than 0.3 microns in size[11]. In contrast, AFL Technology works effectively at 0.1 micron to 0.001 micron, therefore destroying up to 99.997% of all harmful viruses, bacteria, fungi, VOC's and contaminants.

Fig. 8. The LUNA LNT2 Green AFLPCO® unit.

At the core of the Green AFLPCO® Cell, a germicidal UVC lamp deactivates the nucleic acid core of bacteria, viruses and other pathogens, thus destroying their ability to multiply and cause disease. Photons created by the UVC lamp react with our proprietary nano Nickel HCT (contains five reactive metals) catalyst to create a blanket of redundant oxidizers that not only clean the air of bacteria, mold, viruses, VOCs, ethylene and odors, but also sanitize surfaces. The LUNA LNT2 utilizes our proprietary catalyst superior to any

catalyst currently on the market. It contains five rare catalyst metals and nano size particles to increase the kinetic rate of reaction creating millions of redundant oxidizers.

By utilizing a broad-spectrum 254 nm UV lamp, we achieve the same oxidizing and ionizing benefits found in nature created by the sun. Combining the UV light with our nano catalyst and AFL Plasma® (cold plasma) Technology we achieve unparalleled results.

LUNA LNT2 Green AFLPCO® Wallmount Unit and its operation

Intensive research in recent years revealed when Titanium Dioxide (TiO_2) mixed with different metals and elements, can generate negative ions when activated with a UV lamp inside a chamber or cylindrical enclosure. This continuous flow of negative ions can neutralize/inactivate the bacteria and bacterial endospores, viruses, mold spores and harmful VOC (Volatile Organic Compounds) present in the air or a surface.

The LUNA LNT2 unit contains the AFLPCO® technology and is controlled via the High/Low rocker switch located on the bottom panel (Fig. 9C). Depending on contamination levels and area of coverage, the switch should be rocked to either the HIGH or LOW setting and remain on 24 hours a day, 7 days a week. The 'Status Panel' is located on the front of the Luna LNT2. The indicator lights on this panel will provide the user with important information about the operating status of the unit. Each electrical ballast and UVC lamp utilize a separate set of indicator lights to give users detailed status information and ensure individual components are working properly. Should one UVC lamp or ballast fail, the other UVC lamp and ballast can continue to work independently providing continued air purification. The indicator lights can provide users with information about the status of its power and if the UVC lamp needs a replacement.

Air Inlet and Outlet

The Luna LNT2 purifies air by drawing it into the unit through the two rear dust guards. The washable dust guards trap large particulate matter keeping the LUNA LNT2 clean and operating efficiently. Purified air will exit the unit through the forward air outlet. The unit should be installed away from any object that could obstruct the airflow of the air inlet or outlet.

Power adapter

The LUNA LNT2 is powered with a 24 VDC power adapter with a rated input voltage of 100 - 240 VAC and a supply cord. The adapter connects to 110 or 230 VAC 3 amp power cord. The AC power cord is detachable and interchangeable to meet global requirements.

Base Plate

The LUNA LNT2 outer housing is mounted to the lightweight aluminum base plate that protects internal components. The Base Plate features three mounting slots and two mounting holes, making mounting the unit simple.

AFL Plasma®

AFL Plasma® is the latest technology developed by the Research and Development team of the AFL R&D Department. It is incorporated into the machine and uses positive and negative carbon brush electrodes to create the equivalent ions from the natural water vapor in the air[12]. It helps to remove ferrous metals from the air, reduce static charge in a room, which attracts dust, and destroy airborne particulate impurities such as like $PM_{2.5}$.

Ozone is a strong oxidizer that is generally not harmful to mammals at low concentrations, but lethal to microorganisms such as bacteria[13]. A single topical application by nebulization of a low ozone dose completely inhibits the growth of all potentially pathogenic bacterial strains with known resistance to antimicrobial agents[14].

For testing the air purifiers and masks made by the Air For Life (UK), we used an ultra-clean newly built lab at NSB 215 of the Department of Life, Earth & Environmental Sciences, West Texas A&M University, Canyon, Texas, USA, to avoid any contamination or possible errors in the test results. We have conducted tests on emission of Ozone by the air purifiers. We have measured the rate of Ozone emission for the following units built by the Air For Life (UK):

1. LUNA WALL MOUNT SANIFIER®, LNT2-6000
2. AFL MINI SANIFIER®AFL M2
3. AFL CAR SANIFIER®
4. AFL MASK®

We have used *FD-90 Ozone Detector* (Forensics Detectors, USA) to check the Ozone level emitted by the above stated units. We have carried out the tests at the Aerobiology Lab of the West Texas A&M University.

Results and Discussion for Section 2

The results and the photographs taken during the tests are summarized below:

Figures.9A. Set up for testing for the Ozone Emission in the Aerobiology Lab. 9B. Testing with LUNA LNT2-6000 for Ozone Emission. (Initial reading @ 1:54 PM Date January 16, 2020). It showed no Ozone Emission with a reading of 0 ppm. 9C.Testing with LUNA LNT2-6000 for Ozone Emission. 9D. Repeated testing with LUNA LNT2- 6000 for Ozone Emission (Reading @ 2:24 PM on January 17, 2020 after 24 Hr. 30 Minutes).

9E. shows no Ozone Emission from the AFL Mask®. 9F. AFL Car Sanifier shows no Ozone Emission.

Conclusion

The AFL Mask® is very efficient in protecting an individual from all kinds of airborne pathogens and $PM_{2.5}$, thereby proving the best possible PPE (Personal Protective Equipment) available on the market. This mask

can provide an internal air supply within the mask and maximum comfort with its ergonomic design and improved filtration technology.

On repeated testing with replicated experiments and double-blind tests (using different groups of students to perform the same experiment), we found no harmful Ozone emission from the Air Purification Units tested and AFL Mask® built by Air For Life (UK)[15].

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