A Low Cost Air Purifier for Killing Harmful Airborne Microorganisms with a Combination of an Electric-field and an Ultra Violet Light

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Abstract- This work describes the design of a low cost air purifier. The device can suck up the air in a room, kill the microorganisms via an ultraviolet light and an electric field and let clean air flow out. Three electric field types (radial, parallel, perpendicular) were used for an efficient cleaning. Stainless steel meshes were used to increase the density of the electric fields. The instrument was tested against an evaporated bacterial solution. The results showed the instrument is extremely effective when tested against high bacterial concentrations. The instrument is extremely useful to clean air in closed rooms and prevent the spread of airborne diseases.

Keywords: **Air purifier, High electric field, Ultra violet lamp, Microorganisms, Bacteria**

I INTRODUCTION

Harmful microorganisms can be found in air as well as attached to surfaces and are a major threat to human health. The deadly out-break of the corona virus (COVID-19) in 2020 [1] raised the concerns of humans to look at similar cases happened in the past. Several such cases were reported in the past such as, the “severe acute respiratory syndrome” (SARS) in 2003 and H1N1 in 2010. The COVID-19 virus was the deadliest due to several reasons. It could spread from a human or an animal to another when they are in close range (< 2m) by respiratory droplets. Also these respiratory droplets can stay on surfaces and air for several hours and could get in contact with an uninfected person and enter via moth/nose/eye soon as they touch them.

The most common method used to eliminate harmful microorganisms is the chemical method. Several issues related with this method is that, chemicals kill microorganisms selectively; they take time to kill microorganisms completely. As a result, researchers keep on looking for alternative methods.

Effective and low cost air purifiers have the potential to reduce the exposure of humans to virus-laden aerosols in any type of indoor environments. Most air purifiers have filters installed and need to be replaced and disposed as medical waste to prevent any secondary contamination. Most currently available air purifiers have high-efficiency particulate air filters (HEPA) for particles filtration. Using an electric field to clean air have been a known topic in the past, yet has been mostly focused on removing particles [3]. Most of such systems use fibrous filtration although, there is an intrinsic conflict between filtration efficiency, low air resistance, and long service life. Scientists have been struggling to come up with new filter materials to overcome such issues.

As a solution for above mentioned issues, we have designed a simple low cost air purifier which use a combination of an ultra violet (UV) light with a direct high voltage electric field to remove microorganisms in air. The strong multi directional electric field is used to kill microorganisms more effectively. The instrument has been proven to be highly effective against high bacterial concentrations.

II MATERIALS AND METHODS

Two methods were used (UV, High electric field ~ 2000 kV m^{-1}) to kill microorganisms present in air. The high electric field and the UV light. The electric field was divided in to three main parts. A blower was used to suck the air from the environment. The incoming air flows through each chamber in the following order: parallel electric field, UV chamber, perpendicular electric field, and the radial electric field (Figure 1 a). The parallel and perpendicular electric fields were created using two mesh networks (Figure 1-b, c). The radial electric field was created using two cylindrical type mesh networks inside a polyvinyl chloride (PVC) tube (Figure 1-d). The many wire crossing points in the mesh creates a high charge density. The distance between two meshes was maintained at a level which make sure there are no sparks created.

The air flow rate of the instrument was calculated to be 0.188 $m^3\ s^{-1}$. An anemometer (AM 4201) was used to measure the air speed when calculating above parameters.

III RESULTS AND DISCUSSION

The device substantially reduced the bacteria in the airflow. The aerobic plate count of the neat was 6.64 x 108 colony-forming unit (CFU) per milliliter. The two conditions; the control and the activity of UV radiation only, yielded CFU that are impractical to count. The results convinced that the activity of UV radiation used in this device itself was inadequate for air cleaning. The application of the electric field only made an obvious reduction in CFU was observed compared to that of the control or treatment with UV radiation only. The activity of UV radiation and electric field together significantly (P = 0.04) reduced CFU compared to that of the activity of the electric field only (Table 1).

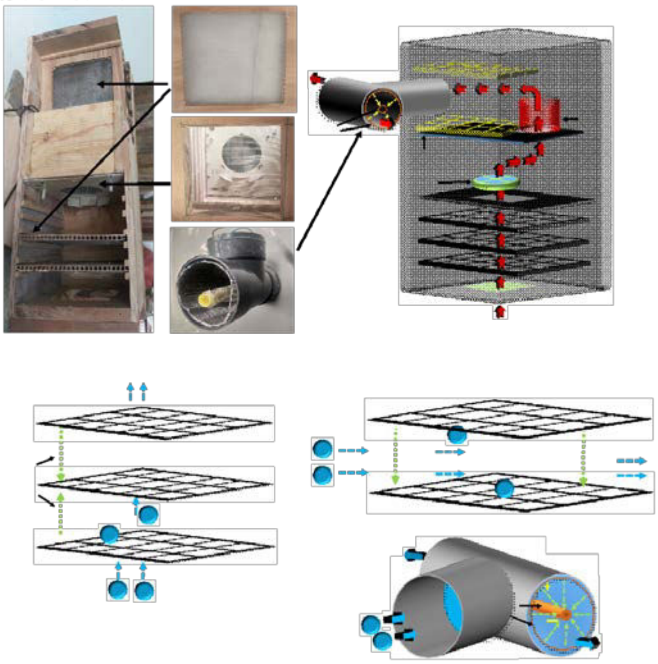

Fig. 1. a) The main components of the E-Field/ UV air purifier with the flow diagram. The three air cleaning electric chambers. b) The parallel electric field (The air flow is parallel to the electric field), c) The perpendicular electric field (The air flow is perpendicular to the electric field), d) The radial electric field (The air flow is radial to the electric field).

The species of bacteria chosen for this experiment, Staphylococcus aureus, is usually found in air as a contaminant. [4].

According to the experimental results the instrument is successful in removing bacterial microorganisms in air. We believe it will be successful against killing viruses such as COVID-19 as well. According to the results the usage of the multidirectional electric field has proven to be effective than a normal unidirectional electric field. The design of the instrument is simple low in cost. l. The instrument can also use as a research instrument to study how microorganisms behave in various types of electric fields.

Table 1 Mean bacterial colony counts observed at the end of incubation at 37 °C for 18 hrs.

Dilution	Mean bacterial colony counts			
	without purification	with UV only	with electric field only	with UV and electric field
Neat	TNC*	TNC	224	210
10^{-1}	TNC	TNC	161	140
10^{-2}	TNC	TNC	90	75
10^{-3}	TNC	TNC	7810	

*TNC: Too numerous to count

IV Conclusion

We were able to use a combination of a high electric field and a UV light to kill microorganisms in air efficiently. The combination of three electric fields is proved to be useful in killing and trapping microorganisms efficiently. The low-cost (100 $) of the instrument has increase the attraction of the instrument in commercial applications compared to the available commercial products in the market (1700 $). The development process is extremely simple and can be achieved under minimum lab facilities.

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