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Non-equilibrium cold plasma technologies for health and agricultural applications

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Dielectric Barrier Discharge (DBD) plasmas, sometimes referred to as atmospheric pressure non-equilibrium cold plasmas, have recently discovered a wide range of cutting-edge applications in biology, medicine, food, agriculture, etc. Such plasmas effectively destroy spores and biofilms, which are highly challenging to inactivate, as well as bacteria, yeasts, moulds, and other potentially harmful microbes including possible bioterrorism agents. Such plasmas can be used to sterilise and remove biological contaminants from surfaces, water, air, food, and even living tissues without endangering them or having any other unintended consequences [1, and references therein]. Several synergistic mechanisms, including electric fields, charged particles, UV rays, produced radicals, and reactive species, can be implicated in such plasma treatments. However, plasma-induced processes are still frequently viewed as an effective "black-box", necessitating a deeper comprehension of these mechanisms, as well as their functions and interrelationships.

A Cold Plasma Group has been created at IIT Jodhpur, which is working on non-equilibrium cold plasmas interventions for health and agriculture applications. Very recently, we have come up with a Cold-plasma Detergent in Environment (CODE) device [2], a surface-DBD based plasma activated water [3], a narrow band 222 nm Excimer UV lamp, and a new geometry cold atmospheric pressure (CAP) plasma jet. These plasma devices are made for particular usages related to quality indoor air, for selective generation of Nitrite and Nitrate for better agriculture yield, for efficiently inactivating drug-resistant bacteria without apparent harm to exposed mammalian skin, and possible use in Endodontics, respectively.

The CODE device effectiveness to deactivate aerosolized bacteria and viruses has been investigated in indoor spaces up to 10 x 8 x 8 ft^3 in size. In 90 minutes of continuous operation of the device at the optimized parameters, the total microbial counts (TMCs) and total fungal counts (TFCs) are decreased to more than 99%. In 30 minutes and 90 minutes of device operation in a contained space, the *MS2 phage* virus and *E. coli* bacteria were completely inactivated with more than 5 log reductions (99.999%). Fig. 1 depicts the device's schematic view.

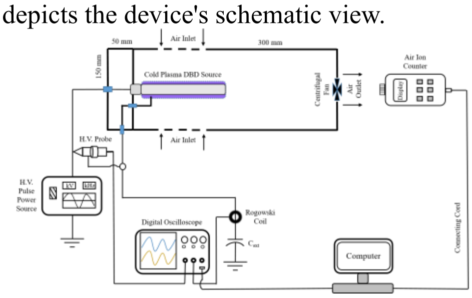

Fig.1 Schematic view of the DBD based Cold-plasma detergent in environment device

The issues addressed are as follows: Enhanced quasi-neutral electric atmosphere, generated hydroxyl radicals without UV, nil ozone and/or nil nascent oxygen, achieved sustenance time of negative ions ~25 sec, dimensionally extendable source, environment friendly.

A low-pressure narrow band 222 nm Far UV-C excimer lamp has also been designed and developed. Generally, at low pressure, a very wide band of spectra having FWHM of 8-15 nm is obtained. The confined gas gap and power source have been optimized and generated a very narrow band spectrum from the excimer source having a FWHM of 1.7 nm. The electrical to optical conversion efficiency as high as 12.5% is obtained. Complete deactivation of two types of microorganisms, i.e., gram-positive (*S. aureus*) and gram-negative (*E. coli*) occurs at the UV dose of 3 mJ/cm^2 and 12 mJ/cm^2, respectively.

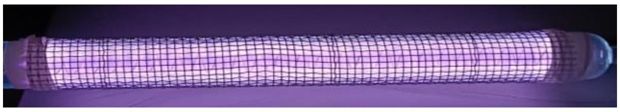

Fig.2. Developed narrow band 222 nm Far UV-C excimer lamp

A surface dielectric barrier discharge-based cold plasma source is also developed with the selective generation of Nitrate and Nitrite in the Plasma Activated Water (PAW). It is inferred that the PAW is enriched with Nitrate and Nitrite, once hydrogen peroxide is nil in the activated water. This type of PAW can be highly useful for agricultural applications. A new geometry CAP helium plasma jet as shown in Fig. 3 has also been designed and developed for endodontics application.

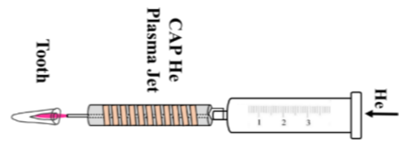

Fig. 3.A new designed CAP Helium Plasma Jet

In this talk a review of these efforts will be presented and strategies will be discussed for the multidisciplinary approach to bring out the real fruits of this emerging area of research.

References

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