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Indoor air decontamination by non-thermal DBD plasma and photocatalysis

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Indoor air contains harmful chemical and biological contaminants. We use non-thermal atmospheric plasma of a dielectric barrier discharge and UV-induced photocatalysis for the treatment of polluted indoor air. The combination of these two technologies is their capability to destroy and completely mineralize the contaminants. The main challenge of this study is to target chemical pollutants, fine and ultrafine particles, and pathogenic bio-aerosols at high gas flow rates (>300 L/min) for a real scale use.

1 Introduction

Indoor air contains many harmful contaminants (chemical pollutants, bacteria, pathogenic aerosols, tobacco smoke, etc.) that can cause respiratory, cardiovascular, and oncological diseases under long-term exposure. Hospital-acquired infections are also spread through air contaminants. Finding an innovative technology that would efficiently remove all airborne pollutants without producing harmful by-products and with a low energy cost would be a major advance for public health. It would also help to prevent the spread of airborne pathogens such as the recent COVID-19 pandemic. Contrary to traditional filters that just trap the contaminants, the goal of this work is to develop non-thermal plasma DBD technology combined with UV-induced photocatalysis for the removal of volatile organic compounds (VOC) [1], fine and ultrafine particulate matter, and inactivation of aerosol-borne bacteria at high gas flow rates relevant for real indoor settings.

2 Experimental

We designed an indoor air decontamination device that combines a DBD and a TiO_2 coating activated on-demand by UV-C lamps or UV-A LEDs. The device uses a very short residence time of the pollutant in the reactor: the gas flow rate is >300 L/min and uses a single-pass method to determine the pollutant reduction.

The chemical analysis of the VOC contaminants (e.g. formaldehyde) and the gaseous species produced by the DBD was performed by FTIR absorption spectroscopy. The water aerosol-borne bacteria *E. coli* and *S. aureus* were collected after a single-pass on Petri dishes and evaluated by thermostatic cultivation.

3 Results

The removal efficiency of 40% was reached for formaldehyde with >300 L/min flow rate in the single pass. We monitored the concentration of ozone generated by the DBD, which must be decomposed by the photocatalytic process before exiting the device. The obtained decontaminations of bio-aerosols are very promising: 3.73 log (99.98%) and 3.32 log (99.95%) inactivation of water aerosol-borne *E. coli* and *S. aureus*, respectively [2].

4 Summary

We developed a new device for indoor air decontamination efficient for chemical (VOC and fine and ultrafine particles) and biological decontaminantion. It employs combined effects of DBD plasma and UV activated TiO_2 photocatalysis. The device can operate at high gas flow rates (>300 L/min). High inactivation of both organic chemical pollutants and airborne bio-pathogens was achieved at a low specific input energy. This combined NTP-photocatalysis technology can be applied in multiple indoor settings, such as hospitals and public spaces, as well as in potential manned space missions.

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References

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