Detailled Program-Book of abstracts

Stability of reactive species produced in plasma-activated water by various atmospheric air discharges and their antimicrobial properties combined with UV-A irradiation

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Although extensive research has been carried out on various applications of plasma-activated water, this study focuses on measuring and understanding the stability and temporal evolution of reactive species therein. It also investigates the enhancement of antibacterial effects of PAW when combined with UV-A irradiation, which is not antibacterial by itself.

1 Introduction

Non-thermal plasma and plasma-activated water (PAW) are used in a vast variety of applications because of their reactive components, especially reactive oxygen and nitrogen species (RONS). PAW is mostly applied in agriculture and food safety, bio-medical applications, and surface treatment and modification. Although extensive research has been carried out on the PAW properties and applications [1], it is crucial to know the stability and temporal evolution of RONS in PAW.

In addition, based on some studies [2], antibacterial and chemical properties of PAW can be enhanced by UV-A radiation. The secondary objective of this study is to investigate the combined effects of plasma treatment with UV-A irradiation [3].

2 Experimental

Both tap and deionized (DI) water are used to produce PAW with three different plasma setups: Transient Spark (TS) batch water treatment, Transient Spark with water electrospray (TS-ES), and Fountain Dielectric Barrier Discharge (FDBD). TS and TS-ES run in pin-to-plane geometries, using a DC high voltage. The spark pulse frequency is fixed at 1 kHz for both, with 1 cm gap distance. 0.5 ml/min flow rate is set for TS-ES, while 10 mL water is treated for 10 min in batch TS. For FDBD a neon-sign AC high voltage supply was used with 15 kV pk-to-pk and 20 kHz, and 1 L of water was circulated during 20 min. Different modes of combined TS + UV-A treatment are examined including plasma alone, UV alone, TS and UV, TS followed by UV, and reverse.

3 Results

PAW characteristics, including the RONS concentrations (H_2O_2, O_3, NO_2^- and NO_3^-), pH, electrical conductivity, oxidation reduction potential (ORP), temperature, and total dissolved solids (TDS), were measured in short and long time after plasma treatment. The PAW physiochemical characteristics were measured in the first 24 h (0, 2, 4, 8, 12, and 24 h) after treatment, and then 1, 2, 4, 8, 16, and 30 days after treatment for a long-time stability. The RONS in naturally buffering tap water are more stable than in DI water, however, most of RONS disappear after 10 days in tap water. All reactions between RONS occur faster in the acidified DI. NO_3^- is the only species that stays in both tap and DI water after a long time.

A significant reduction in bacteria by TS PAW was detected (1.72 log). The combined TS PAW + UV-A treatments for TS+UV and TS then UV resulted in an even stronger log reduction by 2.49 and 2.63, respectively. For UV followed by TS, the result obtained was like that of TS alone. For UV alone, there was no bacterial reduction. These effects can by partly attributed to the UV-photolysis of H_2O and NO_2^-, however, further investigations are required.

4 Summary

The findings obtained from this research are crucial for the post-production use of plasma-activated water in agriculture and disinfection and indicate a potential enhancement of PAW disinfection effects by combining with UV-A irradiation.

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References

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