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Reactive species stability in plasma-activated water generated by different atmospheric pressure plasmas

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Abstract

Because of their unique components, particularly reactive oxygen and nitrogen species (RONS), non-thermal plasma and plasma-activated water (PAW) are used in a wide range of applications. PAW is mostly used in food safety [1] and biomedical applications [2], agriculture, and surface treatment and alterations [3]. Even though a lot of study has been done on the use of PAW [4], understanding the stability and temporal development of reactiveness in PAW is essential.
In this work, three distinct plasma setups—Transient Spark (TS) batch water treatment, Transient Spark-Electrospray (TS-ES), and Fountain Dielectric Barrier Discharge (FDBD)—are employed to generate PAW using both tap and deionized (DI) water. TS and TS-ES use DC high voltage and operate in pin-to-plane geometries. For each, the spark pulse frequency and gap distance are set at 1 kHz and 1 cm, respectively. For TS-ES, a flow rate of 0.5 ml/min was established, while batch TS treated 10 ml for 10 minutes. We utilized a neon-sign AC high-voltage power source with 15 kV pk-to-pk and 20 kHz for FDBD, and we cycled 1 L of water for 20 minutes. PAW characteristics, including the RONS (H_2O_2, O_3, NO_2^-, and NO_3^-) concentrations and pH, electric conductivity (EC), oxidation reduction potential (ORP), temperature, and total dissolved solids (TDS), were investigated in short and long times after plasma treatment. For a short time, the behavior of physiochemical characteristics of water was measured in the first 24 hours (0, 2, 4, 8, 12, and 24 hours) after treatment and 1, 2, 4, 8, 16, and 30 days after treatment for long-term stability. The results show that RONS in naturally buffered tap water are more stable than in DI water; however, most of the 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 tap and DI water after a long time.

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[1] R. Mehrabifard and Z. Machala, "Effect of Plasma Activated Water on Lettuce (Lactuca sativa) Plant Growth and Seed Germination,"SSRN Electron. J., Jun. 2024, doi: 10.2139/ssrn.4871537.
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