Active Species Generation in Gas–liquid Discharge Non-thermal Plasma: Operating Conditions, Influencing Factors, and Mechanisms

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In this study, gas–liquid phase non-thermal plasma in a needle-plate reactor was used to evaluate the generation of active species ($\cdot\text{OH}$, H_2O_2 , and O_3). Specifically, the effects of different factors, including initial pH, conductivity, gas flow rate, and solution circulation flow rate, on the generation of these active species were investigated. Tert-butanol (TBA) was chosen as the scavenger of $\cdot\text{OH}$ given that formaldehyde is a specific product of their reaction. The results showed that the generation of $\cdot\text{OH}$ and H_2O_2 occurs at a faster rate in acidic solutions than in alkaline and neutral solutions. High-conductivity solutions hindered the generation of these active species, which were also affected by the electrolyte type. Further, oxygen and liquid circulation flow rates had little effect on $\cdot\text{OH}$ and H_2O_2 generation in aqueous solutions. However, they exerted a greater impact on ozone mass transfer in gas and liquid phases. Furthermore, the simulation of the effects of UV irradiation, H_2O_2 oxidation, and ozone oxidation on the generation of these active species during discharge showed that individually, UV radiation and ozone oxidation had no significant effect on the generation of $\cdot\text{OH}$ and H_2O_2 . However, various combinations of these processes, especially UV/ O_3 / H_2O_2 and UV/ O_3 , significantly enhanced $\cdot\text{OH}$ production.

Keywords: gas–liquid discharge, non-thermal plasma, active species, hydroxyl radical, mechanism

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