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Cold Atmospheric Plasma Based H2O2 Decontaminant Production And Its On-site And Real-time Diagnostic System

Sooyeon Cho Sungkyunkwan University **Moon Soo Bak** Sungkyunkwan University **Damee Koh** Sungkyunkwan University **Changwoo Son** Sungkyunkwan University **Heesoo Jung** Agency for Defense Development **Kyeong Min Cho** Agency for Defense Development

In response to chemical and biological weapons, the decontamination process is carried out by strong oxidation reactions of chemicals and biological constituents. Among various decontaminants, hydrogen peroxide (H_2O) exhibits exceptional decontamination performance by oxidizing blister agents into non-hygroscopic sulfoketides, sarin into non-toxic isopropyl methylphosphonic acid (IMPA), and VX into non-toxic ethyl methylphosphonic acid (EMPA). Furthermore, H_2O_2 is less corrosive and safer than chlorine-based decontaminants so have been regarded as clean and high-performance decontaminants. However, concentrated H_2O_2 products require careful attention during military transport and on-site storage due to their high reactivity and easy decomposition. Thus, it is highly required to develop decontamination equipment that can instantly decompose water to produce H2O2 decontaminants for rapid decontamination operations.

In this presentation, we introduce a room temperature/atmospheric pressure on-site H_2O_2 decontaminants production system utilizing a dielectric barrier discharge (DBD) plasma reactor. Cold and atmospheric condition of DBD plasma prevents the reversion of produced H_2O_2 back into water. Optimal synthesis and yield enhancement of H_2O_2 via DBD plasma require a complete understanding of the continuous H_2O_2 synthesis reaction. This necessitates the integration of technologies capable of monitoring various ROS in plasma reactors with high sensitivity and selectivity. We have developed a decontaminant production monitoring system that can be integrated into on-site decontaminant production equipment. We developed fluorescent molecular recognition sensors targeting O_2-, OH-, and H_2O_2, and integrated them with a mobile benchtop fiber optics to monitor decontaminant production in real-time. Based on this, we completed a kinetic model for H2O2 production time and final concentration based on plasma operational conditions. By employing aqueous and gaseous kinetic modeling, we identified the primary mechanisms of H2O2 production from the concentrations of OH- in the plasma phase and the concentrations of OH- and H2O2 in the liquid phase. Furthermore, the final decontaminant product was confirmed to be produced above a specific concentration, ensuring on-site quality assurance of decontamination. This study was conducted in collaboration with the Chem-Bio Center of Agency for Defense Development (ADD) in Republic of Korea.

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