MITIGATION - SCIENCE AND TECHNOLOGY ADVANCES FOR CHEMICAL AND BIOLOGICAL CONTAMINATION MITIGATION

Portable Cold Plasma System For Microbial Decontamination

Ketan Bhatt CFD Research Corporation **Vladimir Kolobov** CFD Research Corporation **Gabe Xu** University of Alabama Huntsville **Mary Arugula** CFD Research Corporation **Bhagirath Ghimire** University of Alabama Huntsville **Wesley Grove** CFD Research Corporation **Prabhakar Pandian** CFD Research Corporation

Biowarfare agents (BWAs) pose a significant threat to military personnel and operations. Effective decontamination strategies that eliminate the BWAs prior to human exposure can help minimize consequences and mitigate risks associated with exposure. Traditional “wet” decontamination techniques utilize harsh chemicals (e.g. bleach) and are unsuitable for sensitive equipment (e.g., communications equipment, navigational equipment, computers, and avionics), which cannot be exposed to aqueous decontaminants or caustic solutions. Plasmas consisting of ionized gases, radicals and free electrons can effectively remove all organic contaminants from surfaces and offer a suitable alternative for decontamination of sensitive equipment. Current plasma generation technologies, however, rely on equipment that are bulky and large making them unsuitable for field use. To address this need, CFD Research is developing a novel, portable system that utilizes cold air plasma for biowarfare agent decontamination in the field. The plasma system under development will consist of a hand-held plasma gun connected umbilically to a man-portable base unit featuring the power module and the air pre-conditioning module for humidity and temperature control.

Towards this effort, we utilized multi-physics simulation to model the dynamics of dielectric barrier discharge (DBD) plasma. DBD plasma dynamics consist of two stages – the power deposition stage and the afterglow stage. The dynamics of the power deposition stage are dependent on the applied voltage characteristics, and define the plasma chemistry processes that impact the device's efficiency. On the other hand, the long-timescale plasma chemistry and the species dynamics during the afterglow stage affect the next current pulse causing the so-called “memory” effect. The simulation models were used to design a portable atmospheric plasma jet. The air plasma was produced using 0.2-1 mm diameter nozzles, resulting in visible jets that extend 3-4 mm from the nozzle tip. The plasma temperature was measured to be ~105 °F. Decontamination using air plasma jet was successfully demonstrated using B. thuringiensis and E. coli lawns. The size of the clearance zone was dependent on the nozzle diameter. We also demonstrated the proof-of-concept for material decontamination by demonstrating mitigation of E. coli bacteria and B. thuringiensis endospores on various material coupons deposited using drop-casting.

On-going work is focused on refinement and optimization of the multi-physics simulations using adaptive sampling approaches to improve predictions of plasma dynamics and resultant reactive species. Simulations will guide the design of the next generation air plasma systems for both single-jet and multi-jet systems for treatment of large surfaces. Developed systems will be extensively tested and characterized against a wide variety of materials (plastics, metals, elastomers) of various shapes (rectangular coupons, rods) and surface finishes (matte, smooth, corrugated). An integrated brass-board prototype will be fabricated to evaluate form and function.

The developed system will be marketed to end-users in the biodefense sector for mitigating exposure hazard and providing effective countermeasures. Other target industries include medical devices, textiles, electronics and semiconductors, polymers and plastics, and food & agriculture, where cold plasma can be utilized either for decontamination and sterilization or for surface treatments to engender favorable material properties.

This material is based upon work supported by the Army Contracting Command, Edgewood Contracting Division (ACC ECD) under Contract No. W911SR-22-C-0034