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Characterization Of Simulant And Interferent Aerosol Fluorescence In The Active Standoff Chamber

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To combat chemical and biological weapons developed by rogue nations and terrorist organizations, the U.S. Army has tested various aerosols of biological agents and their simulants in chambers and in the field at U.S. Army Dugway Proving Ground (DPG). The Active Standoff Chamber (ASC) at Dugway Proving Ground (DPG) was initially developed to provide static aerosol challenges for testing light detection and ranging (LiDAR) systems to be used as standoff biological agent detectors. The chamber is a large stainless-steel box with openings on each end large enough to allow standoff interrogation of simulant clouds. Air curtains at each opening prevent the escape of particles, effectively creating a controlled outdoor environment in which static clouds can be maintained, characterized, and left to decay.

The annual Technology, Experimentation, and Characterization Field Trials (TECFT) were conducted in June 2023 at DPG. To characterize simulant and interferent aerosol fluorescence for their detection and classification, a portion of the TECFT event was executed in the ASC, using four bio-simulants [Bacillus atrophaeus (BG), Bacillus thuringiensis variant kurstaki (Btk), Erwinia herbicola (EH), ovalbumin (OV)] and one interferent [Arizona road dust (ARD)] as challenge materials. Realistic aerosol concentrations and particle size distributions were generated in the chamber, during which particle data was recorded with the Wideband Integrated Bioaerosol Sensor (WIBS) detecting bioaerosol particles based on fluorescence measurements in three excitation/emission wavebands on a single particle basis. Single particle analysis using dual wavelength (280nm and 370nm by xenon lamps) excitation on two parallel broadband visible-wavelength detectors (310-400nm and 420-650nm). Particles are classified by a combination of fluorescence excitation and emission characteristics, as well as their optical size measured by forward-scattering using a 635nm continuous-wave diode laser.

Fluorescence signal analysis using particle number concentration exhibited a lower percentage of fluorescent signal in each channel. This was especially true for OV, where it was impossible to discriminate a known biologically fluorescent simulant from ARD. On the other hand, a higher proportion of fluorescence was noted when analyzing fluorescent signal as a function of particle cross sectional area or mass. In both cases, a higher fluorescent signal could be related to particles with higher cross-sectional areas and more mass. Therefore, it can be stated that particles with more cross-sectional area and mass values fluoresce more intensely than those with smaller values. Conversely, when calculating fluorescent fraction by number concentration, the smaller, less fluorescent particles weigh down the percentage of fluorescence intensity. It is strongly recommended to study fluorescence signals relating to cross section area and mass concentrations of aerosol particles, especially in attempts at biological aerosol classification and identification. Since fluorescence intensity varies strongly with size, it is probably necessary to consider cross section area concentration and mass concentration besides the usual focus on number concentration. An analysis of the data produced by the APS and WIBS is summarized and compared in this study.