UV-C decontamination of aerosolized and surface bound single spores and bioclusters

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Biological particles are rarely individual organisms, but are clusters of organisms physically bound to one another, or bound to other material present in the environment. The size and composition of these bioclusters contribute to the protection of the organisms within the core of cluster from the harmful effects of ambient UV light. The use of ultraviolet irradiation has been evaluated in the past as option for decontaminating surfaces and air; however, previous studies were conducted with single spores, or poorly characterized polydispersed aerosols making comparisons between studies difficult. This study is intended to evaluate the effect of UV-C irradiation on monodispersed particles of spore clusters with mean diameters of 2.8 µm and 4.4 µm, and single spores of *Bacillus atrophaeus* subspecies *globigii* (BG) on fixed surfaces and as aerosol.

Ink jet aerosol generator produced clusters and pipetted single spores were deposited on surfaces and were exposed to UV-C irradiation. Similarly, Sono-tek and Collison aerosol generator produced particles in air were exposed to UV-C irradiation. The amount of organism kill was determined after exposures. The D_{90}, the UV-C irradiation doses at which 90% of the colony forming units were rendered non-culturable, for single spores and spore clusters of 2.8 and 4.4 µm diameter on surfaces and in air are provided in Table 1. The decay curves for BG on surfaces and in air are provided in Figures 1 and 2, respectively. The first stage decay rate constant for the surface exposure ranged from 0.012 for single spores to 0.003 for 4.4 µm clusters. Similarly, the aerosol decay rate constant ranged from 0.12 for single spores to 0.04 for 4.4 µm clusters. The results show that single and clustered spores are more rapidly killed when aerosolized than when fixed to a surface. The decay rate of spores contained in clusters is proportional to the overall particle size, and that it is harder to inactivate large clusters on surfaces. Therefore, decay rate based on UV irradiation should consider the following factors: the physical state of the spores, spectrum of light, intensity of irradiation, organism and strain used, and the particle size.

Table 1. The Fluence Values for 90% Kill (D_{90}) of BG spore clusters (2.8 and 4.4 µm) and individual spores on surfaces and in the air.

	D_{90} values for Surface, J/m^2	D_{90} values for Aerosol, J/m^2
Single Spores	138	27
2.8 µm clusters	725	42
4.4 µm clusters	1128	86-94

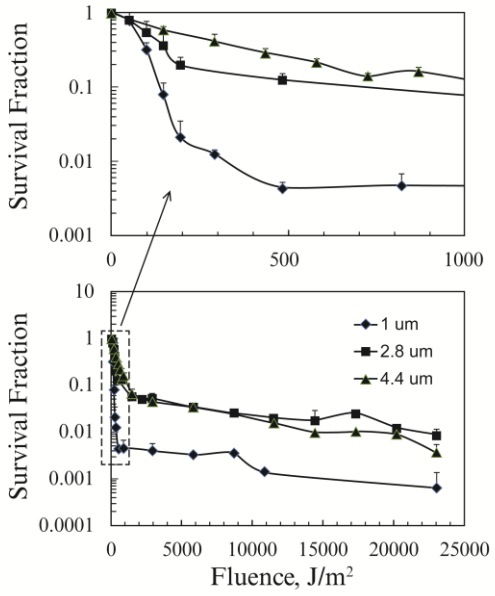

Figure 1. UV-C Survival Fraction (+ standard deviation) curves for the single and BG cluster particles (2.8 and 4.4 µm) deposited on membrane filter surfaces. (Top) survival fraction for fluence up to 1,000 J/m^2. (Bottom) survival fraction for fluence up to approximately 25,000 J/m^2.

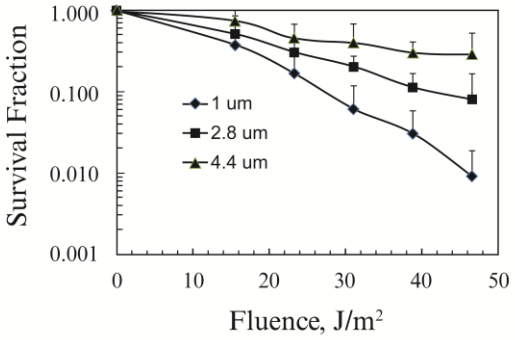

Figure 2. The Survival Fraction (+ standard deviation) curve for aerosolized single and BG clusters (2.8 and 4.4 µm).

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