Research Grant – Successful Submission

Dr Allen Haddrell – Postdoctoral Scholar – Awarded £5000

To Determine the Traits that Regulate the Length of Time a Microorganism Remains Viable While in a Suspended Aerosol, as a Function Atmospheric Conditions

1. Aim of the Project

To characterize and benchmark a novel method I have recently developed to determine how variables (such as humidity, aerosol composition and temperature) affect the longevity and infectivity of various aerosolized bacterial species.

In order to accurately model the airborne spread of disease in a population, the length of time the infectious species remains viable in air is critical. This project will be used to characterize a novel technology I have developed to study this.

2. Programme of Work

Much of the study of bioaerosol longevity over the last half century has been undertaken with the Goldberg drum (GD). There are many drawbacks in the operation of the GD which limit its overall utility. These limitations reside around the control that can be achieved over the environment within the large drum itself (relative humidity, light intensity, [oxidant]) once the bioaerosol is introduced. Bioaerosol is introduced to the GD via nebulisation, a traumatic mechanism by which to produce bioaerosol. Thus the aerosolization process itself will have a detrimental effect on the validity of the findings. Additionally, nebulization will limit the control over the complete composition of each individual droplet. The GD is a bulk analysis technique: an ensemble of bioaerosol is studied at once and only the average response is reported. Thus, there is the need for a robust and convenient instrument capable of making all of the measurements described above on a single bioaerosol droplet.

Over the past year I have developed and refined a novel technology and methodology to:

1) Generate individual bioaerosol droplets of known and controllable chemical composition.
2) Levitate them in an electrodynamic field for extended periods of time (from seconds to days).

3) While levitated, the air in which the bioaerosol is suspended can be completely controlled (e.g. relative humidity (RH), temperature, and ozone concentration).
4) After a specific period of time suspended, the bioaerosol can be readily extracted from the electrodynamic field and deposited onto a cell culture plate containing broth.
5) Agar is added to the broth, and the culture is incubated overnight. The colony forming units (CFU) are then tabulated.

The longevity of the suspended bioaerosol as a function of atmospheric conditions can then be measured through comparing the CFUs between different samples. Moving forward, the aim of this specific project will be to:

1) Establish an appropriate readout mechanism by which the longevity of bioaerosol is reported. Currently, half-lives are presented as the indicator of longevity since current technologies used to study bioaerosol are somewhat limited in their capability. However, given the sensitivity of this new technique (a single bioaerosol particle is studied at a time), a more appropriate metric of longevity may, or may not, be able to be reported.
2) Determine the baseline survival rate for a single cultivated *Escherichia coli* bacteria strain under standard conditions (22 ^{o}C, 50% RH, 0 ppm ozone, ambient light).
3) Systematically measure how relative humidity influences the bioaerosol longevity, and compare these results to those currently published.
4) Determine how the composition of the bioaerosol itself (aside from the bacteria, such as chemical species like salt type/concentration) will affect longevity. Novel to this technology is that droplet-on-demand dispensers are used to generate the bioaerosol. As a result, the complete composition of the bioaerosol can be controlled. Thus components, such as solute type (for example, growth medium vs NaCl vs none), can be varied and the subsequent effect on the species longevity can be probed. This innovative aspect of this technology will allow for the interplay between bioaerosol hygroscopic properties affect the species longevity/infectivity to be probed. In other words, the interplay between the physicochemical properties of the bioaerosol and the biological health of the species therein can be explored.

The results of this suite of experiments will serve as the benchmark by which all the bioaerosol experiments utilizing this technology will be compared with in all future studies.

3. Potential Applications

The breadth of parameters that control the longevity of bioaerosol can be explored with the methodology developed here, and will far exceed anything currently available. For this reason, there is great potential for the measurements from this work to have far reaching implications in the areas of disease dynamics. The innovation described here could become a simple commercial device that would be used by academics to study bioaerosol, and by industries such as air purification and pest control to verify their products prior to them going to market.

The development and interpretation of the outcomes of this technology has required expertise in the field of bacteriology. To that end, I have spent the 18 months nurturing a productive collaboration with Dr. Richard Thomas of the Defence Science and Technology Laboratory (Dstl). Currently, we are preparing a joint review article in the area of this proposal for the journal Applied an Environmental Microbiology.

The longevity of suspended bioaerosol has been studied with the same technology for over the last fifty years. The reliance this technology, that has numerous systemic problems, has potentially hindered the overall understanding of suspended bioaerosol. The development of an improved and more robust and rigorous method will allow for numerous types of studies, and will reinvigorate in this field.

The duration of this project will be 6 months.