Rapid characterization of bacterial motility using Dynamic Light Scattering (DLS)

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Cell motility is an important characteristic of many biological processes, and is ubiquitous in unicellular organisms such as bacteria. The bacterium *Escherichia coli* is a well studied model system for understanding cell motility. These cells execute random walks by alternating between swimming (or running) at speeds of tens of microns per second (for ~1 second), and then tumbling (changing direction) for 0.1 s.

Dynamic light scattering (DLS) has long been used for the measurement of Brownian motion in colloids, proteins and macromolecules, and is a routine technique for the determination of particle size in such Brownian systems. Dynamic light scattering can make accurate measurements over a very short timescale, is non-invasive, requires very little sample, and has a high sensitivity, making it a perfect tool to investigate living biological cells. Early in the development of DLS, its potential for studying bacterial motility was investigated (*e.g.* Nossal, Chen & Lai, 1971), however these investigations were complicated by a lack of understanding of the details of cell motility, as well as equipment limitations, and were never seriously pursued.

In this abstract we report on preliminary investigations of the motility of *E. Coli* using modern dynamic light scattering techniques. We have observed that the correlation functions measured at small scattering angles exhibit two distinct decays: the faster decay being due to the self propelled velocity (motility), and the second, slower decay being due to the normal diffusive motion. These functions were analysed using the model proposed by Nossal, Chen & Lai, and revised by Stock (1978), which was found to provide good agreement under most conditions. This analysis yields the velocity distributions, the average velocities and the fraction of non-motile cells. The diffusion coefficients of the cells can be either an input into the model, or a free parameter. Measurements of non-swimming (dead) cells are also used to obtain independent measures of the diffusion coefficient. We have investigated how the correlation function varies with time, and observed a decrease of average swimming speed as time progresses. The effect of scattering angle for living cells reveals much better theoretical fits at smaller angles, illustrating the effect that the bacteria's tumbling motion has on the correlation function as scattering angle increases.

Finally, we measured the average velocity as a function of temperature over the range 24-37°C. We found that cell motility increases with temperature up to a maximum value at 32°C, where the effect plateaus. The use of DLS for the study of cell motility is an area of research that is ripe for further study.

Nossal, R., Chen, S-H. & Lai, C.C. (1971). Use of laser scattering for quantitative determinations of bacterial motility. *Optics Communications* **4:** 35-39.

Stock, G.B. (1978). The measurement of bacterial translation by photon correlation spectroscopy. *Biophysical Journal* **22:** 79-96.