Tracking of Single Nanoparticles in Living Cells

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Microscopic imaging and tracking of sub-cellular events has revolutionized our understanding of cellular transport mechanisms, and brought ground breaking discoveries of cellular functioning and activities. With the rise of nanotechnology, and especially of application of nanoparticles in biomedical research, it is essential to visualise nanoparticle interactions in sub-cellular environment. However, real-time observation of nanoparticles and sub-cellular mechanisms in living cells has been constrained by limited selection of nanosensors. One of the biggest hurdles to observe single nanoparticles is their sub-diffraction limit size and in-efficient light emission to be detected by standard detectors.
In this work,[1] we demonstrate a library of mono-disperse and emission-tunable upconversion nanoparticles (UCNPs), each emits highly, uniform, bright and photo-stable signals for long-term quantitative analysis of single nanoparticles. We can detect UCNPs not only in simulated environments, but also in living cells with high temporal, spectral and spatial resolutions using standard microscopic setup. In addition, we prove that in order to identify fluorescence (colour and position) of single nanoparticle, luminescence of single nanoparticles should be more than 4000 photons per 100 milliseconds. We track UCNPs inside living cells with high precision over time allowing us to determine nanoparticle diffusion, location and transport. Additionally, we show that the technique for real-time discrimination of single nanoparticles further allows nanoscale measurement of the local viscosity and forces of intracellular environment. Furthermore, beyond colour recognition of each single nanoparticle, we introduce additional dimension to detect single nanoparticles emitting the same colour. The methods is based on the excitation power density to simultaneously distinguish multiple sets of single nanoparticles, where nanoparticles doped with different doping concentration can emit light at the different excitation densities.

References

1. F. Wang, S. Wen, H. He, B. Wang, Z. Zhou, O. Shimoni and D. Jin, Light: Science & Applications 7, 18007 (2018).