Polysaccharide coated upconversion nanoparticles for imaging intracellular mechanisms

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Introduction:

Fluorescent nanomaterials are promising for combining diagnostics and therapeutics into a single system, leading to more precise and capable tools for early diagnosis and treatment of diseases. Upconversion nanoparticles (UCNPs) are an exceptionally photostable nanomaterial that is ideal for bio-imaging as they are excited by deep-penetrating near-infrared light but emit in ultraviolet, visible or near-infrared wavelengths [1]. We have created novel polysacharride coated UCNPs via ligand exchange that are highly hydrophilic and colloidally stable due to the presence of negatively charged sugars on them. These novel luminescent materials can be used for quantitative imaging with super resolution microscopy and for understanding intracellular mechanisms.

Aims:

To make hydrophobic UCNPs hydrophilic by the use of charged polysaccharides for application in super resolution microscopy to understand and image intracellular mechanisms.

Methods:

Surface functionalization of 4% Tm doped NaYF4 UCNPs was done using the ligand exchange method where UCNPs were mixed with fucoidan or colominic acid and kept for overnight shaking. Zetasizer and dynamic light scattering (DLS) measurements were used to analyse the surface functionalisation along with a lectin binding assay. Transmission electron microscopy was used to image UCNPs before and after functionalisation. Cellular uptake studies were performed using different human cell lines to visualise receptor specific uptake with confocal and superresolution microscopy techniques such as SEE and STED.

Results:

The conversion of hydrophobic UCNPs to hydrophilic UCNPs was confirmed by zeta potential, DLS and AAl-FITC co-localisation assays. Zeta potential indicated the change in charge from neutral to highly negatively charge whereas DLS measurements indicated a change in the size of particles ranging from 70nm – 90 nm. AAL-FITC and WGA-FITC bound to Fucoidan-UCNPs and colominic acid-UCNPs, respectively, and co-localised luminescence indicated the presence of sugars on UCNPs. A time based analysis of particle uptake showed increasing UCNP concentrations over time from 1 hour to 16 hours post treatment.

Discussion:

We have demonstrated that fucoidan and colominic acid sugars convert UCNPs into a hydrophilic state while maintaining their stability and dispersion in aqueous phase. These sugar-coated UCNPs were used to determine sugar specific receptor mediated uptake. Further, by the use of superresolution microscopy, single particles were observed inside cells.

Conclusion:

Hence, our novel polysaccharide coated UCNPs are highly biocompatible and has the potential to explore the intracellular mechanisms via live cell imaging.

References

1. Chen, S., et al., Near-infrared deep brain stimulation via upconversion nanoparticle–mediated optogenetics. Science, 2018. **359**(6376): p. 679-684.