# Hydrophilic Surface Modification of Upconversion Nanoparticles for LRET-based DNA Assays

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# CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Yingzhu Zhou declare that this thesis, submitted in fulfilment of the requirements for the award of master by research, in the Faculty of Science at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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List of Publication

[1] Yinghui Chen, Hien T. T. Duong, Shihui Wen, Chao Mi, **Yingzhu Zhou**, Olga Shimoni, Stella M. Valenzuela, and Dayong Jin,'Exonuclease III-Assisted Upconversion Resonance Energy Transfer in a Wash-Free Suspension DNA Assay'，*Analytical Chemistry, 2018,90 (1), 663-668.*

[2] **Yingzhu Zhou**, Yinghui Chen, Hao He, Jiayan Liao, Hien T. T. Duong, Maryam Parviz, and Dayong Jin, 'A Homogeneous DNA Assay by Recovering Inhibited Emission of Rare Earth Ions-Doped Upconversion Nanoparticles', *Journal of Rare Earths.* Doi:10.1016/j.jre.2018.05.008.

[3] Wei Ren, **Yingzhu Zhou**, Shihui Wen, Hao He, Gungun Lin, Deming Liu and Dayong Jin, *Chem. Commun*.doi:10.1039/C8CC04200D

# Abstract

Upconversion nanoparticles (UCNPs) are emerging as a new-generation optical nanomaterial that has drawn tremendous research interests. UCNPs can sequentially absorb two or more lower-energy photons in near-infrared (NIR) range to emit one higher energy photon, typically in the visible and ultraviolet range. This anti-Stokes' property offers a great deal of opportunities in biological and analytical applications, because NIR excites negligible amount of autofluorescence background in visible range that is an issue in conventional methods using UV or visible excitation. Furthermore, UCNPs are biocompatible, resistant to photobleaching and photoblinking, tunable in size, morphology, and composition. All these characteristics offer their potentials in diverse applications, including bioassays, chemical detections, bio-imaging, single-molecule tracking, thermometers, security inks, and photothermal therapy etc.

UCNPs are used in aqueous suspension, in particular, biomedical and analytical applications for targets recognition and detection, which requires a hydrophilic surface. However, UCNPs are synthesised in the organic solvent with the inherent hydrophobic surface. The key is to modify their surface from being hydrophobic into hydrophilic. Among a series of surface modification strategies, ligand exchange stands out because of its simplicity, and versatility for further conjugations with functional groups.

This thesis focuses on a systematic study of the hydrophilic surface modification methods to identify a one-step ligand exchange strategy for UCNPs. Based on this study, development of a robust homogenous assay, based on Luminescence Resonance Energy Transfer (LRET), is also demonstrated to achieve detection of DNA disease biomarkers. In this thesis, Chapter I covers the objectives, structure and organization; Chapter II gives the detailed literature review and the the introduction of UCNPs; followed by Chapter III, a systematical evaluation of the performance of four common polymers in transferring the surface of UCNPs from being hydrophobic to hydrophilic. Chapter IV reports the

development of a platform for DNA detection in homogeneous solutions based on LRET, which work has been published as a peer-reviewed article.

**Keywords:** Upconversion nanoparticles, surface modifications, ligand exchange, LRET, homogenous DNA detection

# Contents

# Figures

## Tables