Chemical & Physical Sciences
UNIVERSITY OF TORONTO
MISSISSAUGA

COLLOQUIUM

TUESDAY, JANUARY 10TH, 2012
12:00 P.M. (SHARP) – 1:00 P.M.
CCT 2150

Frank C.J.M. van Veggel

University of Victoria

"NEW NANOPARTICLES FOR OPTICAL AND MAGNETIC RESONANCE IMAGING"

I will describe our recent results on colloidal Ln^{3+} doped nanoparticles and lead chalcogenide based quantum dots for application as optical and magnetic resonance imaging agents. With respect to the optical properties we have an emphasis on the biological window, i.e. the near-infrared range roughly from 700 to 1300 nm, where tissue is more transparent than to UV-visible light, thus providing an opportunity for deep-tissue imaging. The general strategy to improve the optical properties is to make core-shell structures in order to reduce quenching processes. In addition, we develop better T_1 and T_2 contrast agents for magnetic resonance imaging (MRI). The synthesis and basic characterisation of the nanoparticles and quantum dots will briefly be discussed, with some emphasis on the challenges to prove the actual formation of core-shell structures. To this end, advanced high-resolution electron microscopy and energy-dependent X-ray photo-electron spectroscopy, the latter at the Canadian Light Source, will be discussed.

The major part of the talk will focus on the advantages and disadvantages of Ln^{3+} doped nanoparticles for optical bio-imaging using a non-linear process known as upconversion, that convert two or more low energy photons into one of higher energy. The Yb^{3+}/Tm^{3+} combination is able to convert 980 nm CW laser light, through absorption by Yb^{3+}, into 800 nm emission, through Tm^{3+}. The low absorption efficiency and slow photocycle make Ln^{3+} doped nanoparticles poor candidates for imaging in a scanning mode, with a stack of x-y scans giving depth resolution in the z direction. However, by using a CCD camera, it proved possible to get lateral and depth resolution of the blood vessels in the brain of a sedated mouse. Strategies to overcome these problems will be presented. Additionally, progress on T_1 and T_2 contrast agents for MRI will be discussed and the conjugation to antibodies to impart bio-specificity (i.e. for prostate cancer).

The first task to explore the possibilities of lead chalcogenide based quantum dots is to make them water-dispersible with retention of the photoluminescence. We have developed several methods to transfer these quantum dots to aqueous media, pH buffers, and other biological media with retention of the photoluminescence. The fact that they have higher two-photon absorption cross sections than organic fluorophores and that their emission can be tuned to the biological window are clear opportunities for deep-tissue imaging. Preliminary results will be discussed on quantum structures with an aspect ratio, i.e. quantum rods, which show polarised emission with correlation times that can be tuned from the nano- to the microsecond range. This gives a unique probe for time-resolved binding studies of protein-protein, protein-DNA interactions, etc.