THE UNIVERSITY OF ARIZONA
COLLEGE OF ENGINEERING
Biomedical Engineering

BME IS PROUD TO ANNOUNCE THE DOCTORAL DEFENSE OF

PETER DAWSON

BME PhD Candidate

“Development of NaYF4:Yb, Tm Upconverting Nanoparticles as a Nano-Tool for Near-Infrared to Ultraviolet Photochemistry”

Abstract: A major problem which stymies the use of some photochemical techniques for biomedical use is the requisite ultraviolet (UV) radiation to initiate chemical reactions. UV covers the range of the electromagnetic spectrum from 10 to 400 nm. The majority of UV initiated photochemistry occurs within the range of 280 to 380 nm which constitutes the UVA and UVB. However, this range of UV is affiliated with carcinomas, DNA damage, immune modulation and mitochondrial damage. Upconversion nanoparticles (UNPs) have the ability absorb multiple near-infrared (NIR) photons to produce emission with a higher energy than any of the individual absorbed photons ranging from higher energy NIR to UVB emissions. By utilizing NIR excitation, one can drive photochemical reactions in biological environments at the site of the UNPs rather than direct UV radiation to the culture or tissue. The biological spectral window includes the NIR between 700 and 1350 nm which is fortunately includes the range of excitation wavelengths in UNPs occur. This presents a serendipitous opportunity to develop systems for NIR triggered photochemical reactions without the need for a continuous dose of UV irradiation.

There are multiple preparative techniques which control the amount of UV production within UNPs. We utilize two means of synthetic controls in the form of doping and architecture. There are two primary dopants in UNPs: sensitizers which are responsible for absorbing the excitation photons, and activators which are responsible for emitting the higher energy photons. We found multiple relationships between the level of sensitizer doping and UV emission of UNPs. We also utilized a core and shell architecture which demonstrated significant improvement in UV emission. Based on the geometry of upconversion nanoparticles and known distances governing energetic interactions we proposed a new architecture for UNPs which could serve as a template for energy transfer kinetics in UNPs.

After synthesis, multiple avenues of manipulating the UV state still occur. The first and most ubiquitous example of controlling UV is the power dependence on excitation in this multiphoton process. Another, and less obvious, technique for precisely controlling the UV emission involves modulation of the pulse width of the excitation source. There, we were able to control the UV output over three orders of magnitude while maintaining a steady level of the NIR to NIR upconversion. This modality allows the continuous tracking particles using NIR imaging and, with the turn of a dial, initiation photochemistry using the UV output of these UNPs.

Finally, based on the rates of energetic interactions we have made strides in pursuing a new type of UV upconversion which promotes formation of UV energy levels, with alternative pathways to depopulation such that UV emission is quenched but energy transfer may occur if appropriate photochemical substrate is present. We call this NIR activated photochemistry without UV emission “silent upconversion.”

Please join us on
THURSDAY, DECEMBER 12TH, 2019
MEDICAL RESEARCH BUILDING (MRB) 102
11:00 AM
HOST: DR. MAREK ROMANOWSKI