Development of a photonic transformer: Using heterogeneous chemical environments to manipulate two-photon phenomena

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Objective

We have identified a previously unreported and efficient near-infra red (NIR) two-photon phenomenon in a heterocyclic aromatic molecule that does not require high power light sources. We propose this as a solution for the *in situ* photo-uncaging of bioactive molecules *in vivo*.

Background

NIR light is able to penetrate tissues and is thus an attractive energy source for photo-responsive *in-vivo* drug delivery. However, the low energy of NIR photons reduces their efficacy as a driving force for a photochemical event. Multi-photon phenomena can overcome this problem. These transitions occur at very low rates and usually require high power photonic sources to increase their likelihood. We have shown it is possible to use a heterogeneous chemical environment to stabilize energy states, allowing for low probability electronic transitions to occur at an increased rate.

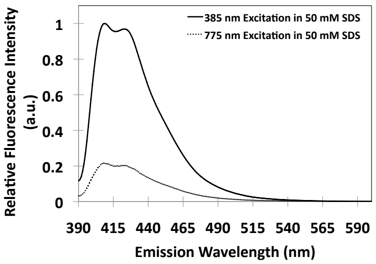
Methods

A combination of absorption and fluorescence spectroscopy was used to probe the excited states of the heterocyclic molecule in sodium dodecyl sulfate (SDS) micelles.

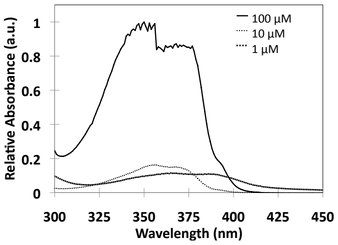
Results

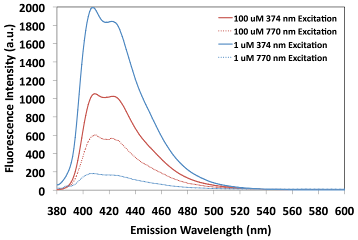
Fluorescence spectroscopy results show that the heterocyclic molecule can undergo efficient two-photon transitions at 775 nm to produce a fluorescent signal with an emission maximum of 410 nm. The efficiency of this effect is high, 20% of that when the molecule is excited at the excitation maximum (384 nm). We have shown that there is concentration dependence to the efficiency of the two-photon excitation indicating excimer formation. The two-photon effect is also micelle dependent, suggesting that the molecule is distributed toward the head group of the detergent molecules.

Two-photon excitation at 775 nm induces fluorescent emission at 410 nm

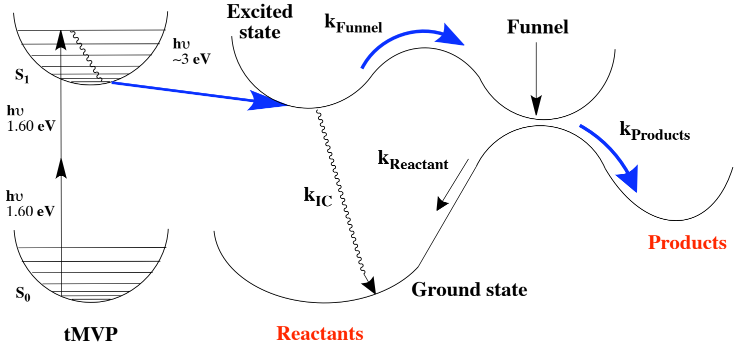


Fluorescence emission spectra indicate two photon excitation with 775 nm light. The efficiency of this excitation was concentration dependent. This was reflected by the non-linear concentration dependence of absorption spectra below a concentration of 10 μM.

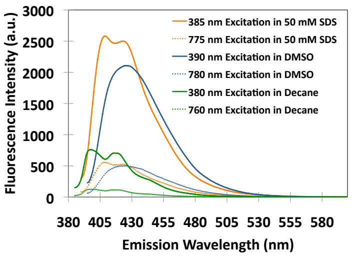




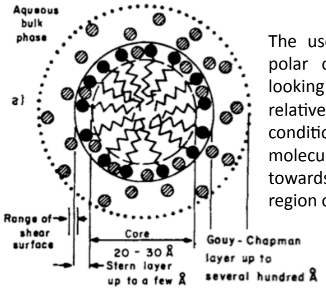
Energy can be transferred to an acceptor molecule to power a photochemical event



Heterogeneous chemical environments facilitate two-photon excitation



Two-photon excitation efficiency is diminished in non-polar solvents. Exposure to electrical fields is known to increase two-photon excitation efficiency.



The use of polar and non-polar organic solvents and looking at their shifts, relative to the SDS micelle condition indicates that the molecule is distributed towards the head group region of the micelle.

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Conclusions

We have generated a molecular system, by manipulating the chemical environment, which can transform photonic energy. We propose that the light emitted from the heterocyclic molecule can power a photochemical event.

Acknowledgements

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