CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

Michael D. Wu

Project Number

S0631

Project Title

A Solar Powered Upconverting Nanoreactor for Highly Efficient Photochemical Synthesis

Abstract

Objectives/Goals

Achieving solar powered photochemical synthesis has been the dream of chemists since Ciamician in 1912. Yet due to issues with current reactors and the inability of visible light to catalyze organic reactions, photochemistry has achieved limited applications in the real world.

The two objectives of this project are to improve upon existing synthesis technology by harnessing TTA upconversion in a solar powered microfluidic nanoreactor and to synthesize ascaridole more efficiently. This project aims to increase the real-world applications of photochemistry.

Methods/Materials

The novel upconverting nanoreactor was fabricated and then used to synthesize ascaridole. Its efficiency and yields were compared to current synthesis techniques, batch and clear microfluidics, as controls.

To fabricate the upconverting reactor, the Vaporization of a Sacrificial Component process was used to create a 35microliter channel embedded inside the polyurethane host. To harness upconversion processes inside the polymer, the uncured urethane was doped with PdOEP and DPA. Through triplet-triplet annihilation, these dyes will upconvert green to blue photons.

Ascaridole was synthesized by flowing a solution of a-terpinene, Ru(bpy), methanol, and oxygen through the microchannel under 1.3 sun illumination. The product was collected, evaporated, run through a silica plug, and analyzed using absorption and NMR spectroscopy.

Results

Upconversion capabilities were successfully harnessed inside the polymer of a microfluidic nanoreactor, increasing the intensity of blue light inside the microchannel. The blue light emissions matched the excitation wavelengths of Ru(bpy) perfectly, more optimally sensitizing singlet oxygen and thus synthesizing more ascaridole. Once upconversion was added to the reactor, concentrations of ascaridole increased 86% when compared to current microfluidic technology, a significant improvement in yield.

Conclusions/Discussion

Harnessing upconversion in a nanoreactor is a significant improvement to existing organic synthesis techniques. When compared to batch reactors, it has higher efficiency and can be easier scaled up and when compared to microfluidics, it has significantly higher yields.

Moreover, the upconverting microfluidic nanoreactor can synthesize other important medicines and fuel using only solar energy as its energy source with applications industrially, in rural hospitals, and developing nations.

Summary Statement

This project significantly improved current microfluidic technology by harnessing upconversion processes in the reactor, increasing yield and real world applicability of photochemistry.

Help Received

I did my research project in the Esser-Kahn Lab at the University of California, Irvine. Dr. Rachel Steinhardt from the group was an inspirational mentor, providing guidance and training along the way.