CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

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Project Number

S0624

Project Title

Harnessing Photon Upconversion in a Microfluidic Reactor for Ultra-Efficient, Solar-Driven Photochemical Synthesis

Abstract

Objectives/Goals

Achieving solar powered photochemical synthesis has long been the dream of scientists. Unfortunately, flaws with existing photochemical reactors and the solar spectrum's lack of high intensity, specified wavelengths of light necessary for organic syntheses have historically prevented large-scale applications of photochemistry. To address these challenges, this project continuously flows reagents through a novel reactor which harnesses upconversion. Upconversion concentrates only the required catalytic blue light from solar illumination without increasing thermal stain. Enabled by upconversion, this project presents a solar-powered reactor for the more efficient microfluidic synthesis of pharmaceuticals and other compounds.

Methods/Materials

The novelty and challenge of this experiment lies in effectively harnessing upconversion inside a microfluidic reactor. Tygon tubing was suspended in a specialized mold and surrounded with an upconverting polymer comprised of polyurethane and 9,10-DPA, PdOEP dyes.

The efficiency of the reactor was tested by synthesizing ascaridole, a crucial anti-parasitic drug.

A-terpinene, oxygen, and the photosensitizer ru(bpy) were flowed through the microchannel at varying flow rates and illuminated with 1.12 suns. Each flow rate was tested 3 times. Product analyzed using gas chromatography and NMR spectroscopy.

The experiment was repeated to synthesize rose oxide, an important fragrance, to further display industrial applicability.

Results

After experimentation, the upconverting reactor improved ascaridole conversion by 400% compared to existing microfluidics technology. 66% of starting reactant was converted to rose oxide with the novel reactor, compared >1% from controls. Combined with the increased conversion, quicker flow rate and wider tubing diameter of the novel reactor, ascaridole production output was increased 35 times compared to the best microfluidics. The reactor was simulated using COMSOL Multiphysics and optimized for 100% product conversion.

Conclusions/Discussion

Harnessing upconversion in a microfluidic reactor represents a breakthrough in photochemical synthesis techniques. The solar-powered reactor has far-reaching applications: providing on-demand pharmaceutical relief for Syrian refugee camps to treat the Leishmaniasis outbreak, improving the medical infrastructure of developing nations, and more sustainable and cost-efficient industrial manufacturing.

Summary Statement

This project enhances microfluidic photochemical syntheses through photon upconversion and has extensive applications industrially, treating outbreaks in Syrian refugee camps, and improving the medical infrastructure of developing nations.

Help Received

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