Engineering an Upconversion Photocatalyst for Energy and Environmental Applications

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Certain materials possess the ability to harness energy from light to facilitate reactions. These photocatalysts present an opportunity for providing a sustainable way to solve energy and environmental problems related to the byproducts of industrial processes. They can be used to facilitate the degradation of stable, water-based pollutants, or they can be used to convert carbon dioxide to carbon monoxide, which can be then be converted to hydrocarbon fuels by the Fischer-Tropsch process. However the most prevalent photocatalyst, titanium dioxide, can only utilize light with frequencies in the ultraviolet range which only makes up three percent of the solar spectrum. This project attempts to solve this problem by doping a titania photocatalyst with two rare earth ions, erbium and ytterbium, which will interact with the light in what is known as an upconversion process. This two-step photon process involves both rare earth ions and the oxide structure and takes lower frequency light and “upconverts” it to the UV range, which can increase the efficiency of the photocatalyst will be enhanced. Different compositions of these photocatalysts were synthesized via a hydrothermal process and characterized for structure, surface area, particle size, and bandgap. The produced photocatalysts were used in a water-phase reactor to degrade a solution of Rose Bengal dye, which has stable benzene rings that mimic the water-based pollutants. The photocatalysts were subjected to various frequencies of light produced by different LEDs to study the effect of upconversion on photocatalytic efficiency, and the contribution the structure to the catalytic properties of the photocatalyst.

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