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A hybrid molecular-nanocrystal platform for photon upconversion

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Third generation photovoltaics are inexpensive modules that promise power conversion efficiencies (PCEs) exceeding the thermodynamic Shockley-Queisser limit, perhaps by using up- or down-converters, intermediate band solar cells, tandem cells, hot carrier devices, or multi-exciton generation (MEG). Here, I introduce a hybrid platform comprised of semiconductor nanocrystals and organic semiconductor molecules that can efficiently upconvert light of visible and infrared wavelengths, at excitation densities below the solar flux. For example, colloidally synthesized core-shell lead sulfide -cadmium sulfide nanocrystals (NCs), in combination with tetracene derivatives, absorb near infrared (NIR) light and emit visible light at 560 nm with an upconversion quantum yield (QY) of 8.4 ± 1.0 %. This is achieved with NIR cw excitation at 3.2 mW/cm^2, approximately three times lower than the available solar flux and about a million times lower excitation densities than state of the art lanthanide-based upconversion materials, for comparable QYs. The molecular and nanocrystal engineering here paves the way towards utilizing this hybrid upconversion platform in photovoltaics, photodetectors and photocatalysis.

Ming Lee Tang is the Assistant Professor in the department of Chemistry, and Material Science and Engineering at the University of California, Riverside. Her research group focuses on the design, synthesis and characterization of novel hybrid organic-inorganic materials. . Emphasis is on the synthesis of tailor-made organic ligands designed to control, enhance or mediate the optoelectronic properties of nanocrystals (NCs).

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