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TITLE: Quantum Dot Nanotechnology for Solar Energy Applications

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A major limiting factor of solar energy conversion into electricity via photovoltaic (solar) cells is its relative inefficiency. A practical solution to this problem can come from quantum dot nanotechnology. The quantum dot approach provides an avenue to improve current solar cell configurations as well as contribute towards the development of future solar cells. Nanotechnology constitutes novel phenomena and properties through the control of matter on the nanometer length scale (1-100 nm). Quantum dots are semiconductor nanocrystals that confine electrons in all three spatial dimensions and are usually less than 10 nm in diameter. At this scale, unique characteristics are observed which make them far superior to bulk semiconductors.

Adjusting the optical and electrical properties of bulk semiconductors is difficult since their bandgap is fixed. Quantum dots offer versatility in this aspect. The smaller the dot, the shorter the wavelength of light absorbed and emitted, the larger the bandgap hence the greater the energy. To maximize solar-electric energy conversion, different-sized quantum dots are used. Quantum dot nanotechnology research has shown that applications in solar energy are in progress. Quantum dots due to their size-tunable optical properties can be engineered to access the short-wavelength infrared region of the solar spectrum in infrared photovoltaic. In solar concentrators, quantum dots are replaced by the dye to achieve increased stability, tunability and efficiency. The quantum dots coat a transparent sheet which allows sunlight to be absorbed and re-radiated isotropically.

Projections for quantum dot application in solar energy include: the rainbow solar cell and multiple exciton generation (MEG). The theory of the rainbow cell is to orderly arrange different sized cadmium selenide (CdSe) quantum dots onto a titanium oxide (TiO₂) nanostructure. This design offer an expanse absorption range and high electron injection rates. It has been demonstrated that the absorption of a single photon by a quantum dot yields three electron-hole pairs (excitons) rather than one. These phenomenons can effectively double the efficiency of the solar cell. To meet the world's growing energy demand, quantum dot nanotechnology seems to be that third generation semiconductor device scientists have been searching for that is low cost due to ease of fabrication and has a tunable bandgap so can therefore harvest more light in the solar spectrum.