Geometric Manipulation of Cuprous Oxide Nanocrystal Surface Morphology Enhances Photoelectrochemical Properties and Enables Fabrication of Low-Cost, High Efficiency Photovoltaic Cells

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Delicate manipulation of nanocrystal morphology and surface structure is crucial in order to synthesize particles with specific electrochemical properties. In this study, cuprous oxide (Cu2O) nanocrystals were fabricated and utilized in the creation of highly stable and efficacious photocathodes for use in solar technologies. The selective surface stabilization of Cu2O nanocrystals by the capping molecule polyvinylpyrrolidone (PVP) allows for further modification into distinct morphological structures–nanocubes and nanooctahedrons–each with distinct electrochemical properties. The structural stabilities of different Cu2O nanocrystal facets were assessed by comparing the electrochemical stability of {100}-bound nanocubes and {111}-bound nanooctahedrons. The photocatalytic activities and efficiencies of electrodes composed of Cu2O {100}-nanocubes and {111}-nanooctahedrons were also compared in order to appraise their suitability for constructing highly efficient and economical photocathodes. Both Cu2O nanocube and nanooctahedron electrodes demonstrated higher photocatalytic responses to light and greater stabilities than conventional silicon-based solar panels, resisting degradation at higher equivalent energies for longer periods of time compared to current silicon technologies. These novel Cu2O solar cells were determined to be more highly optimized for use within the solar emission spectrum, improving upon silicon-based cells' maximum experimental efficiency of 21.5%, achieving 53.6% and 62.7% efficiency in the nanocube and nanooctahedron cells, respectively, indicating their promise as a new, inexpensive material suitable for the production of clean, renewable energy.

Awards Won:
United States Steel Corporation: Third Place Award of $750