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A Review of Transition Metal Sulfides as Counter Electrodes for Dye-Sensitized and Quantum Dot-Sensitized Solar Cells

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Abstract

Third-generation solar cells, including dye-sensitized solar cells (DSSCs) and quantum dot-sensitized solar cells (QDSSCs), have been associated with low-cost material requirements, simple fabrication processes, and mechanical robustness. Hence, counter electrodes (CEs) are a critical component for the functionality of these solar cells. Although platinum (Pt)-based CEs have been dominant in CE fabrication, they are costly and have limited market availability. Therefore, it is important to find alternative materials to overcome these issues. Transition metal chalcogenides (TMCs) and transition metal dichalcogenides (TMDs) have demonstrated capabilities as a more cost-effective alternative to Pt materials. This advantage has been attributed to their strong electrocatalytic activity, excellent thermal stability, tunability of bandgap energies, and variable crystalline morphologies. In this study, a comprehensive review of the major components and working principles of the DSSC and QDSSC are presented. In developing CEs for DSSCs and QDSSCs, various TMS materials synthesized through several techniques are thoroughly reviewed. The performance efficiencies of DSSCs and QDSSCs resulting from TMS-based CEs are subjected to in-depth comparative analysis with Pt-based CEs. Thus, the power conversion efficiency (PCE), fill factor (FF), short circuit current density (Jsc) and open circuit voltage (Voc) are investigated. Based on this review, the PCEs for DSSCs and QDSSCs are found to range from 5.37 to 9.80% (I−/I3− redox couple electrolyte) and 1.62 to 6.70% (S−2/Sx− electrolyte). This review seeks to navigate the future direction of TMS-based CEs towards the performance efficiency improvement of DSSCs and QDSSCs in the most cost-effective and environmentally friendly manner. © 2023 by the authors.

Author Keywords

counter electrode; dye-sensitized solar cell; materials performance; polysulfide electrolyte; quantum dot-sensitized solar cell; transition metal sulfide

Index Keywords

Conversion efficiency, Cost effectiveness, Electrodes, Inorganic compounds, Nanocrystals, Open circuit voltage, Polyelectrolytes, Semiconductor quantum dots, Sulfur compounds, Transition metals; Cost effective, Counter electrodes, Dye- sensitized solar cells, Material performance, Polysulphide electrolyte, Polysulphides, Quantum dot-sensitized solar cells, Quantum dots-sensitized solar cells, Quantum-dot-sensitized solar cells, Transition metal sulfides; Dye-sensitized solar cells

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