

Zeolitic Imidazolate Framework-Derived ZnSe/Carbon/PEDOT:PSS as the Counter Electrode for Dye-Sensitized Solar Cells

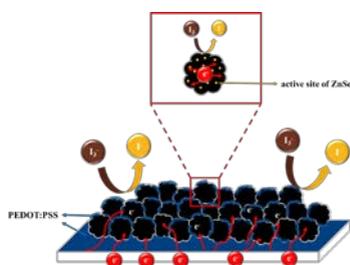
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Recently, metal-organic frameworks (MOFs) have received extensive attention as a class of porous crystalline materials, which are composed of metal ions/clusters and coordinated organic ligands. These materials possess unique structural topology and tunable functionalities that are useful for gas absorption, separation, catalysis, dye-sensitized solar cells (DSSCs), and so on. Zeolitic imidazolate frameworks (ZIFs), which are composed of tetrahedrally-coordinate transition metal ions connected by imidazolate linkers, are a class of MOFs that are topologically isomorphic with zeolites.

In this study, we synthesized zinc selenide carbonaceous material (ZnSe-C) derived from ZIF-7 as the counter electrode (CE) in DSSCs. A composite film composed of ZnSe-C and poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS), designated as ZnSe-C-P, was prepared for the counter electrode via a drop-coating method. The overall electron transfer pathway is hierarchical; the electron transfers from the substrate to PEDOT:PSS and passes through the ZnSe-C particles. The electrical conductivity inside ZnSe-C is mainly dominated by carbonization. PEDOT:PSS improves the electrical conductivity on the surface of the particles and among the particles; it also works as a binder between the composite film and the FTO substrate. And there are many electro-catalytic active sites on the ZnSe-C particles, triggering the reduction reaction of triiodide (I_3^-) (Scheme. 1). In Fig. 1, owing to the combination of the advantages of both ZnSe-C and PEDOT:PSS, the DSSC with the best ZnSe-C-P composite counter electrode rendered a photovoltaic conversion efficiency (η) of $8.69 \pm 0.13\%$, which is higher than that of the cell with a Pt CE ($8.26 \pm 0.02\%$), suggesting that ZnSe-C-P has an excellent electrical conductivity and good electro-catalytic ability toward I_3^- reduction. Fig. 2 shows cyclic voltammograms (CV) of various electro-catalytic films. Among these CEs, ZnSe-C-P has the highest value of the peak current density, once again confirms that it has good electro-catalytic ability toward I_3^- reduction. Moreover, the peak-to-peak separation (ΔE_p) of ZnSe-C-P is smaller than those of the bare ZnSe-C and bare PEDOT:PSS, showing that it is easier to trigger the redox reaction. This study concludes that CE based on ZnSe-C-P is a prospective substitute to Pt and could provide new opportunities for advancing high-efficiency DSSCs.



Scheme 1 The sketch of the electron transfer pathways in the CE of the composite optimized ZnSe-C-P.

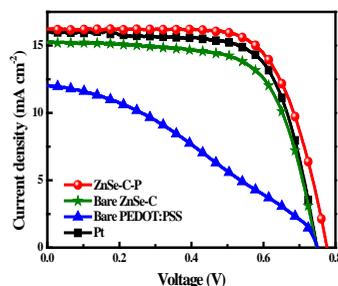


Fig. 1 Photocurrent density–voltage (J – V) curves of the DSSCs with the CEs of the bare ZnSe-C, bare PEDOT:PSS, optimized ZnSe-C-P, and Pt.

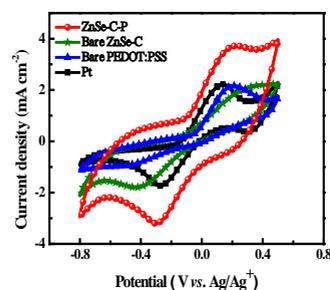


Fig. 2 Cyclic voltammograms of I^-/I_3^- redox couple on the CEs of the bare ZnSe-C, bare PEDOT:PSS, optimized ZnSe-C-P, and Pt.