Supramolecular Photovoltaic Cells of Porphyrin-Peptide Oligomers With Fullerene Clusters

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The development of organic solar cells that mimic natural photosynthesis in the conversion and storage of solar energy has merited significant interest as inexpensive renewable energy sources. We have recently reported that a combination of porphyrin assemblies such as porphyrin-alkanethiolate monolayer protected-gold nanoclusters and porphyrin dendrimers with fullerene clusters provides an ideal system for organic solar cells fulfilling an enhanced light-harvesting efficiency of chromophores throughout the solar spectrum and a highly efficient photocurrent generation.[1,2] We report herein novel photovoltaic cells composed of porphyrin-peptide oligomers (the octamer is shown in Figure 1)[3] and fullerene clusters, which are deposited on nanostructured SnO_2 electrodes.

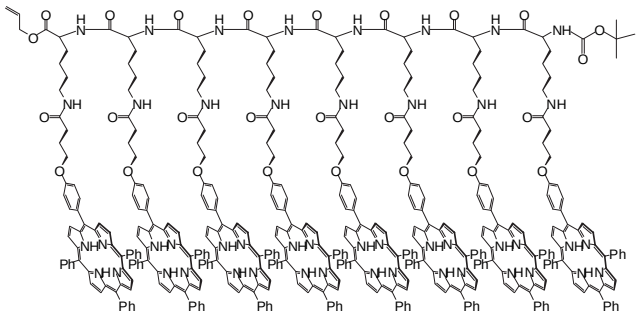

Figure 1. Porphyrin-peptide octamer $P(H_2P)_8$ used in this study.

Composite molecular nanoclusters of fullerene and porphyrin-peptide octamer prepared in acetonitrile/toluene mixed solvent absorb light over entire spectrum of visible light. The highly colored composite clusters of C_{60} with porphyrin-peptide octamer can be assembled to an optically transparent electrode (OTE) of nanostructured SnO_2 (OTE/SnO_2), to provide a modified electrode [denoted as $OTE/SnO_2/(P(H_2P)_8+C_{60})_m$] using an electrophoretic deposition method.

Photocurrent measurements of $OTE/SnO_2/(P(H_2P)_8+C_{60})_m$ were performed in acetonitrile containing NaI (0.5 M) and I_2 (0.01 M) as redox electrolyte and a Pt gauge counter electrode. The photocurrent action spectrum is shown in Figure 2, which is in parallel with the broad absorption spectrum of $OTE/SnO_2/(P(H_2P)_8+C_{60})_m$. The IPCE values were calculated by normalizing the photocurrent values for incident light energy and intensity. The IPCE value reaches 33% which is much higher than that of the reference system using the porphyrin monomer. This indicates that the π-π interaction between porphyrins

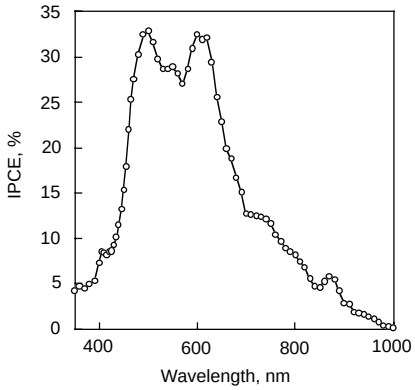

Figure 2. The photocurrent action spectra (IPCE vs wavelength) of $OTE/SnO_2/(P(H_2P)_8+C_{60})_m$ ($[H_2P]$ = 0.19 mM, $[C_{60}]$ = 0.31 mM).

and fullerenes in the supramolecular clusters of porhyrin-peptide octamer plays an important role in improving the light energy conversion efficiency as the case of supramolecular organic photovoltaic cells of fullerene clusters with porphyrin-alkanethiolate monolayer protected-gold nanoclusters and porphyrin dendrimers.[1,2]

We have also determined the power conversion efficiency (η) of the photoelectrochemical cell by varying the load resistance (Figure 3). The $OTE/SnO_2/(P(H_2P)_8+C_{60})_m$ system has a much larger fill factor (*FF*) of 0.35, open circuit voltage (V_{oc}) of 300 mV, short circuit current density (I_{sc}) of 0.5 mA cm^{-2}, and the overall power conversion efficiency (η) of 0.75% at input power (W_{in}) of 6.8 mW cm^{-2} as compared with the reference system (η = 0.035% for $OTE/SnO_2/(H_2Pref+C_{60})_m$).

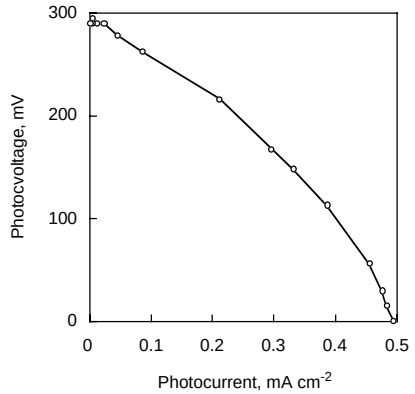

Figure 3. Power characteriscs of $OTE/SnO_2/(P(H_2P)_8+C_{60})_m$ under visible light illumination (λ > 400 nm); electrolyte 0.5 M NaI and 0.01 M I_2 in acetonitrile.

Such remarkable enhancement in the photoelectrochemical performance as well as broader photoresponse in the visible and infrared relative to the reference system demonstrates that a combination of porphyrin-peptide oligomers and fullerene clusters provides novel perspective for the development of efficient organic solar cells.

References

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