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Design and Characterization of Novel Porphyrins with Oligo(phenylethynyl) Links of Varied Length for Dye-Sensitized Solar Cells: Synthesis and Optical, Electrochemical, and Photovoltaic Investigation

Author(s): Lin, CY (Lin, Ching-Yao)¹; Lo, CF (Lo, Chen-Fu)¹; Luo, L (Luo, Liyang)^{2,3,4}; Lu, HP (Lu, Hsueh-Pei)^{2,3}; Hung, CS (Hung, Chen-Shiung)⁴; Diau, EWG (Diau, Eric Wei-Guang)^{2,3}

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Abstract: Novel zinc porphyrins with 1-4 pi-conjugated phenylethynyl (PE) units (labeled PE1-PE4) as a link of controlled length were synthesized for fundamental tests and applications as a dye-sensitized solar cell (DSSC). The UV-visible spectra of the solution samples show clear absorption patterns of the PE groups in a region 300-400 nm, consistent with results calculated with density-functional theory. Cyclic voltammograms of PE1-PE4 in tetrahydrofuran show similar electrochemical potentials for each compound. Femtosecond fluorescence up-conversion of solution samples and of porphyrin-sensitized TiO₂ films was measured with excitation at 420 or 430 nm and emission at 460, 470, 620, and 680 nm. When these porphyrins were fabricated into DSSC devices, the efficiency of power conversion of these devices decreased systematically with increasing length of the link: 2.5 +/- 0.2% (PE1), 2.0 +/- 0.1% (PE2), 0.78 +/- 0.09% (PE3), 0.25 +/- 0.02% (PE4). This great photovoltaic degradation from PE1 to PE4 is not interpretable according to the rate of electron injection independent of length; other factors, including electron transfer from the semiconductor back to the porphyrin cation or the electrolyte, must be considered to account for the observed dependence of photovoltaic performance on length.

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Reprint Address: Lin, CY (reprint author), Natl Chi Nan Univ, Dept Appl Chem, Puli 545, Nantou, Taiwan

Addresses:

1. Natl Chi Nan Univ, Dept Appl Chem, Puli 545, Nantou, Taiwan
2. Natl Chiao Tung Univ, Dept Appl Chem, Hsinchu 300, Taiwan
3. Natl Chiao Tung Univ, Inst Mol Sci, Hsinchu 300, Taiwan
4. Acad Sinica, Inst Chem, Taipei 115, Taiwan

E-mail Address: cyl@ncnu.edu.tw; diau@mail.nctu.edu.tw

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
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