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Efficiency Enhancement in Mesogenic - Phthalocyanine - Based Bulk Heterojunction Solar Cell By Using Solvent Mixtures

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はじめに：A mesogenic phthalocyanine derivative, 1,4,8,11,15,18,22,25-octahexylphthalocyanine ($C6PcH_2$) has been demonstrated as a promising small molecule for use in bulk heterojunction (BHJ) solar cells.[1] $C6PcH_2$ exhibits not only excellent processability for thin films but also appropriate electronic characteristics for a solar cell, such as a deep highest occupied molecular orbital energy level, a relatively small band gap, strong optical absorption, and high hole and electron drift mobilities exceeding 1.4 $cm^2V^{-1}s^{-1}$ and 0.5 $cm^2V^{-1}s^{-1}$ in the crystalline phase, respectively. Despite their prominent characteristics, solar cells, in which the active layer was composed of $C6PcH_2$ and a fullerene derivative, 1-(3-methoxy-carbonyl)-propyl-1-1-phenyl-(6,6)C_{61} (PCBM), showed relatively low power conversion efficiency (PCE).[2] Herein, we report the high performance of $C6PcH_2$:PCBM BHJ solar cells fabricated with separated phases using solvent mixtures.

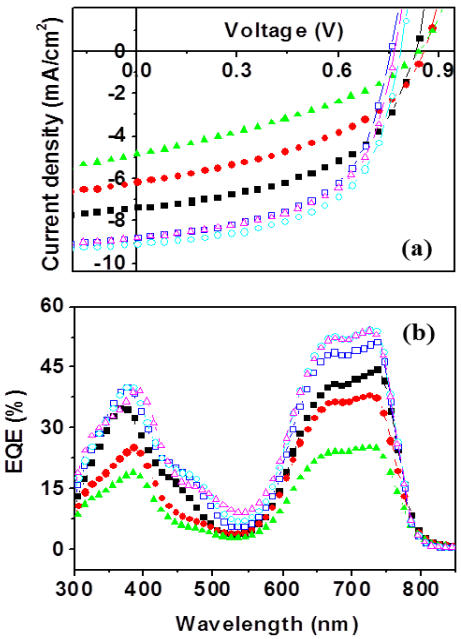

Fig. 1: J-V characteristics (a) and EQE spectra (b) of cells with DIO (empty symbols) and without DIO (filled symbols) in the various solvents: chloroform (triangles), TCE (circles), and toluene (rectangles)

実験：MoO_x films were thermally evaporated onto ITO substrates. A solution containing a mixture of $C6PcH_2$:PCBM (2:1) in various solvents with an additive, such as 1,8-diiodooctane (DIO), was spin-cast onto a MoO_x layer. Finally, a LiF buffer layer and an aluminum layer were deposited through a shadow mask by thermal evaporation.

結果：As shown in Fig. 1a, the $C6PcH_2$:PCBM devices without DIO in toluene showed a PCE of 3.1%, with a short-circuit current density (J_{sc}) of 7.4 mA/cm^2, an open-circuit voltage (V_{oc}) of 0.83 V, and a fill factor (FF) of 0.50. By using DIO to control the nanomorphology, the performance of BHJ solar cells was markedly improved. As depicted in Fig. 1b, by adding 0.2% v/v DIO to toluene, the external quantum efficiency was improved from 48% to 54% at the Q-band and the shoulder of the B-band emerged at 450 nm and the PCE increased to 3.7% with a J_{sc} of 8.7 mA/cm^2 and a FF of 0.55. Further, by incorporating 0.2% v/v of 1,8-dibromooctane to chloroform, the J_{sc} and the PCE increased to 9.7 mA/cm^2 and 4.2%, respectively. [4]

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