High efficient solar cell utilizing phthalocyanine-tetrabenzoporphyrin hybrid macrocycles

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Introduction: Recently, solution-processable mesogenic phthalocyanine has been demonstrated as a novel type of small-molecule semiconductors for bulk heterojunction (BHJ) organic solar cells (OSCs).[1,2)] On the other hand, the relatively high charge carrier mobility and a deep highest occupied molecular orbital energy level of the phthalocyanine must be available for hole transport material (HTM) layer in perovskite solar cells (PSCs). Herein, we report the recent progresses in solar cells using mesogenic phthalocyanine.

Results and discussion: *Improving photovoltaic performance of the BHJ OSCs by using various phthalocyanine-tetrabenzoporphyrin hybrid macrocycles and tandem structure*: By replacement of aza links in the eighteen-π-electron cores of phthalocyanine species by methine links, the bandgap energy increased and the absorption at B-band were improved. The BHJ OSC utilizing tetrabenzotriazaporphyrin, which possesses one methine groups and three aza links at meso position, exhibited the highest efficiency exceeding 5.3%.[1,2)] Furthermore, the tandem solar cell utilizing a conventional structure composed of phthalocyanine and poly(3-hexylthiophene) was fabricated. The tandem solar cells covered the all visible spectral range and the high photovoltaic performance was achieved.[3)]

High efficiency of the PSC using mesogenic phthalocyanine HTM layer: we demonstrate how mesogenic phthalocyanine can be a suitable HTM layer for efficient PSCs. The energy levels and the photoluminescence quenching of perovskite/phthalocyanine heterojunction films indicated that the perovskite/phthalocyanine heterojunctions within the photoactive region can dissociate charges and the phthalocyanine can play a role as a HTM layer. By using phthalocyanine in combination with methylammonium lead iodide perovskite, a final device efficiency of 11.5% is achieved (Fig. 1(b)).

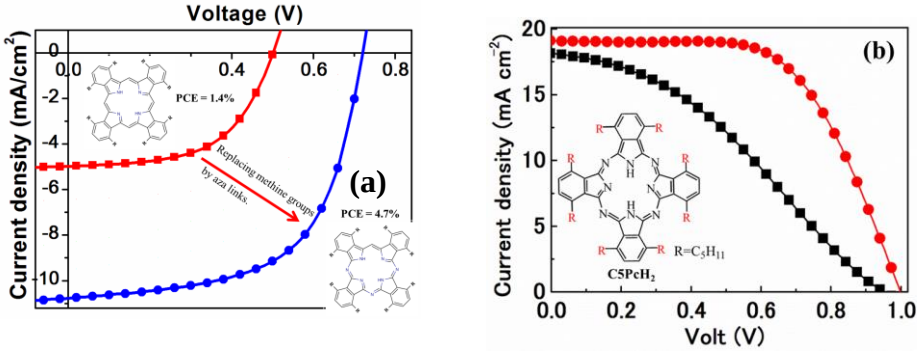

Fig. 1: J-V characteristics of (a) BHJ OSCs using various phthalocyanine-tetrabenzoporphyrin macrocycles and (b) PSCs utilizing $C5PcH_2$ HTM layer without (rectangles) and with (circles) annealing at 130 ºC for 10 min.

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References: [1]Q.D. Dao *et al.*, *Chem. Lett.* **43**, (2014) 1761.[2]Q.D. Dao *et al.*, *Org. Electron.*, **23**, (2015) 44.
[3]Q.D. Dao *et al.*,*Jpn. J. Appl. Phys.* **55**, (2016) 03DB01.