Supporting Information

Enhanced efficiency in small-molecule organic photovoltaic cells by a pyrene dimer morphology control layer

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Figure S1. (a) J–V characteristics and (b) IPCE spectra of the [1DPy / C60] OPVs and absorbance per thickness of 1DPy and C60.

Table S1. Performance of the ITO/PEDOT: PSS (30 nm)/1DPy (60 nm)/C60 (40 nm)/BCP (10 nm)/Al devices.

<table>
<thead>
<tr>
<th>Donor</th>
<th>Jsc (mA/cm²)</th>
<th>Voc (V)</th>
<th>FF (%)</th>
<th>PCE (%)</th>
<th>RSe (ohm·cm²)</th>
<th>Rsh (ohm·cm²)</th>
<th>@-1.0V (mA/cm²)</th>
<th>@1.0V (mA/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1DPy only</td>
<td>1.11</td>
<td>0.90</td>
<td>0.34</td>
<td>0.34</td>
<td>349</td>
<td>1340</td>
<td>-1.84</td>
<td>0.37</td>
</tr>
</tbody>
</table>

We show the device performance using 1DPy as a $p$-type layer (Figure S2, Table S1). The $J_{SC}$ of the 1DPy/C$_{60}$ device is low, because the absorption of 1DPy overlaps with the absorption of C$_{60}$ in ultraviolet area. It is notable that the $V_{OC}$ is relatively large. This is consistent with the higher HOMO level of 1DPy than that of pentacene, CuPc and DBP. Although FF and $R_{Se}$ are relatively low, 1DPy shows the obvious electron-donor feature in an OPV device.
Figure S2. J–V characteristics of the [pentacene/C_{60}] OPVs with an 1DPy or NPD ABL.

![Figure S2](image)

Figure S3. (a) Chemical structure of DIB-SB, (b) J–V characteristics and (c) IPCE spectra of the [DIB-SQ / C_{60}] OPVs with an 1DPy ABL.

![Figure S3](image)

Table S2. Performance of the ITO/PEDOT:PSS (30 nm)/1DPy (0 or 1 nm)/DIB-SQ (20 nm)/C_{60} (40 nm)/BCP (10 nm)/Al devices.

<table>
<thead>
<tr>
<th></th>
<th>Jsc (mA/cm²)</th>
<th>Voc (V)</th>
<th>FF</th>
<th>PCE (%)</th>
<th>R_{se} (ohm·cm²)</th>
<th>R_{sh} (ohm·cm²)</th>
<th>@1.0V (mA/cm²)</th>
<th>@1.0V (mA/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIB-SQ</td>
<td>4.08</td>
<td>0.84</td>
<td>0.47</td>
<td>1.60</td>
<td>33.0</td>
<td>635</td>
<td>-5.55</td>
<td>10.0</td>
</tr>
<tr>
<td>with 1DPy</td>
<td>5.03</td>
<td>0.85</td>
<td>0.46</td>
<td>1.91</td>
<td>29.4</td>
<td>562</td>
<td>-6.48</td>
<td>9.60</td>
</tr>
</tbody>
</table>

We fabricated devices based on a DIB-SQ, which is not aromatic hydrocarbon molecules, donor layer with a thickness 20 nm instead of pentacene (Figure S3, Table S2). The J_{sc} values of the DIB-SQ devices increased with the insertion of 1 nm of 1DPy and resulted in enhancements of the PCE.
from 1.60% to 1.91%. The IPCE spectra were improved in the absorption wavelength range of the 
C₆₀ especially. The behavior of J-V curves as inserting 1DPy is similar to CuPc or DBP. These 
results also supported our explanation that the intended grain control by 1DPy can be achieved to a 
pentacene layer probably because of specific intermolecular π-π interaction. However 1DPy is still 
useful to increase JSC of the devices with CuPc, DBP, SIB-SQ.