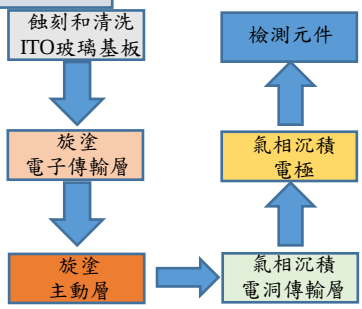
111材料工程系大學部
實習成果觀摩競賽

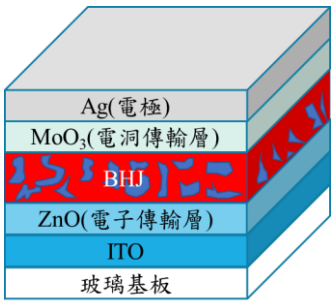
藉由小分子Donor作為第三元材料實現高性能三元有機太陽能電池

摘要

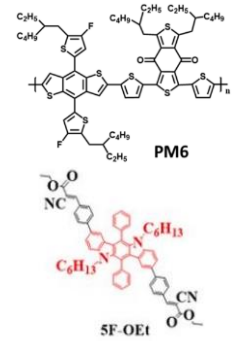
目前有機太陽能電池的效率達17~18%，而主動層在有機太陽能電池中占據了關鍵地位，而近幾年使用多組成主動層來製備三元混摻有機太陽能電池是高潛力和有效的，本研究是在高效率有機材料(PM6:Y6)混摻由東海大學張源杰教授提供的5F系列材料，優化有機太陽能電池的光吸收、混和型態、電荷提取時間、激子壽命和抑制雙分子/陷阱輔助重組，最佳效率達17.64%。

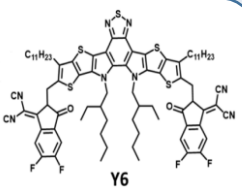
實驗部分





元件結構

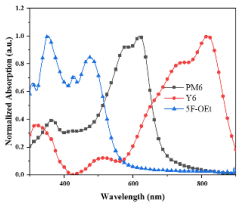




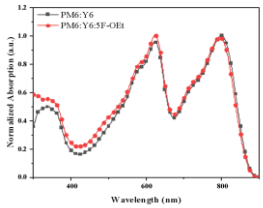
主動層材料化學結構

結果和討論

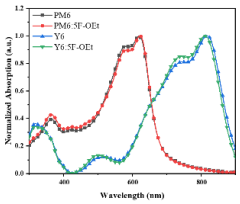
Optical properties



(a) 單材料的UV光譜圖



(b) 二元和三元的UV光譜圖

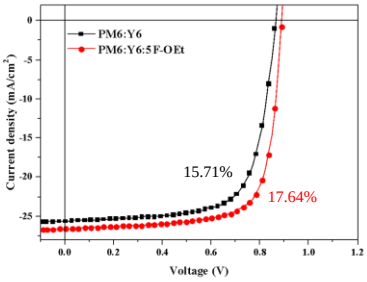


(c) PM6、Y6、PM6:5F-OEt和Y6:5F-OEt的UV光譜圖

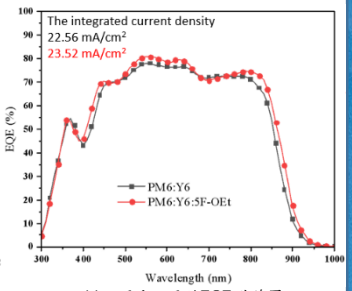
表(1) 單材料、二元和三元的吸收峰位置

Sample	λ_{max} of PM6 (nm)	λ_{max} of Y6 (nm)
PM6	620.5	-
Y6	-	819
PM6:5F-OEt	622	-
Y6:5F-OEt	-	812
PM6:Y6	623.5	799
PM6:Y6:5F-OEt	623.5	794.5

Device performance



(d) 二元和三元的J-V Curve圖

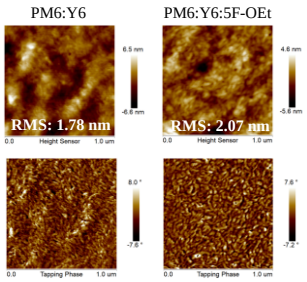


(e) 二元和三元的EQE 曲線圖

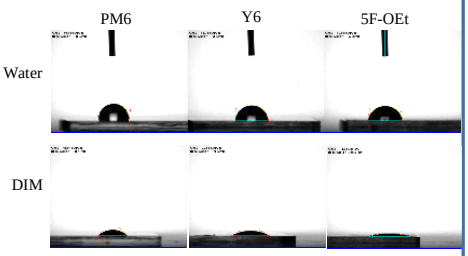
表(2) 二元和三元的標準差數據表

PM6:Y6:5F-OEt	Jsc (mA cm^2)	Voc (V)	FF (%)	PCE (%)	PCE_{best} (%)
1:1.2:0	25.18±0.24	0.865±0.002	71.08±0.81	15.51±0.19	15.71
1:1.2:0.07	25.84±0.60	0.891±0.003	74.60±0.65	17.17±0.28	17.64

Morphology



(f) 混和膜的表面型態圖



(g) 單材料的接觸角圖

表(3) 單材料的表面能、χ值和ω值數據表

	Polar (mN/m)	Dispersive (mN/m)	Surface energy (mN/m^{-1})	χ_{PM6-X}	χ_{Y6-X}	ω
PM6	1.90	38.33	40.22	-	0.53	-
Y6	5.44	44.58	50.03	0.53	-	-
5F-OEt	6.71	49.25	55.97	1.30	0.17	-2.22

表(4) χ值和ω值算式表

Flory-Huggins interaction parameters (χ) $\chi \propto (\sqrt{\gamma_D} - \sqrt{\gamma_A})^2$

Wetting coefficient (ω)

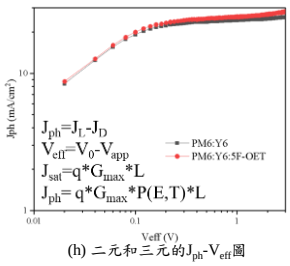
$$\omega_{third\ component} = \frac{\gamma_{third\ component-acceptor} - \gamma_{third\ component-donor}}{\gamma_{donor-acceptor}}$$

(ω>1), will be located in the donor domain

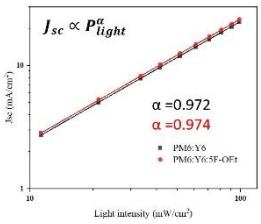
(ω<-1), thwill be located in the acceptor domain

(1>ω>-1) will be located at the interface between donor and acceptor.

Recombination



(h) 二元和三元的J_{ph}-V_{eff}圖



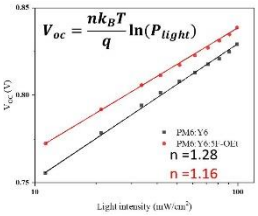
(i) 二元和三元的J_{SC} –light intensity

表(5) 二元和三元的J_{ph}-V_{eff}數據表

	G_{max} (m^{-3} s^{-1})	P (E,T) (%)
PM6:Y6	1.58x10^{-28}	95.73
PM6:Y6:5F-OEt	1.65x10^{-28}	92.91

J_{sat}: Value of J_{ph} under conditions where the value of V_{eff} was 2.5 V.

J_{ph}*: Value of J_{ph} under short-circuit conditions.



(j) 二元和三元的V_{OC} –light intensity

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