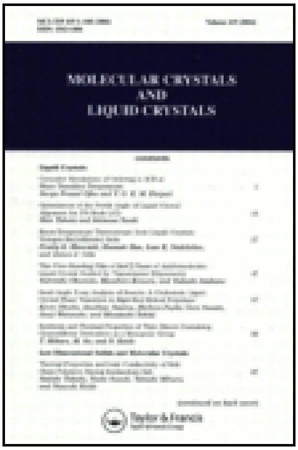

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Photovoltaic Properties of Pvk Based Films with 5,10,15,20-Tetra(O-Nitrophenyl) Porphyrinatozinc and 8-Hydroquinoline Aluminum

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Photovoltaic Properties of Pvk Based Films with 5,10,15,20-Tetra(*O*-Nitrophenyl) Porphyrinatozinc and 8-Hydroquinoline Aluminum

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5,10,15,20-Tetra(*o*-nitrophenyl)porphyrinatozinc (ZnTNPP) and 8-hydroquinoline aluminum (Alq_3) were used as *p*-type and *n*-type semiconductors. We fabricated three types of cells; ITO/PVK (ZnTNPP)/Al, ITO/PVK(ZnTNPP+Alq_3)/Al and ITO/PVK(ZnTNPP)/ Alq_3/Al. We found that the cell with a *p-n* junction structure had better conversion efficiency. In the ITO/PVK(ZnTNPP)/Alq_3/Al cell, photovoltaic parameters were V_{oc}= 0.94 V, J_{sc} = 0.62 $\mu A/cm^2$, FF = 0.211 and η = 0.48%.

Keywords: porphyrin; photovoltaic; solar cell; *p-n* junction

INTRODUCTION

Due to the abundance of organic materials having a variety of absorptions and their potential low-cost fabrication, a large number of organic solar cells have been investigated. Recently there have been many attempts to fabricate *p-n* heterojunction cells with organic dyes and polymers [1]-[3]. We fabricated ITO/PVK(ZnTNPP)/Al, ITO/PVK (ZnTNPP+Alq_3)/Al and ITO/PVK(ZnTNPP)/Alq_3/Al cells and investigated their photovoltaic properties. 0.48% of conversion efficiency is obtained.

EXPERIMENTAL

The chemical structures of the dyes used are illustrated in Figure 1. 5,10,15,20-Tetra(*o*-nitrophenyl)porphyrinatozinc (ZnTNPP) and 8-hydroquinoline aluminum (Alq_3) were used as the p-type and n-type semiconductors, respectively. ZnTNPP was synthesized by literature method [4]. Alq_3 and poly(*N*-vinylcarbazole) (PVK) were purchased from Aldrich, and used as received. PVK (0.1 g) was dissolved in tetrachloroethane (4.8 g), then ZnTNPP (0.1 g) was added. Another film containing ZnTNPP and Alq_3 was fabricated as follows. PVK (0.1 g) was dissolved in tetrachloroethane (4.8 g), and ZnTNPP (0.05 g) and Alq_3 (0.05 g) were added. The solutions were passed through 0.2 μm filters and then spin-coated at 1000 rpm on ITO glass substrate and dried at 50 °C for 12 h. Alq_3 film (100 nm) was vacuum deposited on the PVK film at 10^{-5} Torr. Finally, Al electrodes (100 nm) were deposited on the organic films. The depositon rate was kept below 0.2 nm/s. The photovoltaic measurements were carried out using an electrometer (Keithley, model 237) under irradiation of monochromatic light (420 nm) from a 150 W Xenon lamp. The optical absorption spectra were recorded on a Perkin-Elmer Lambda-20 spectrophotmeter.

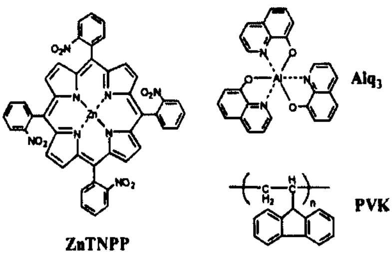

FIGURE 1 The chemical structures of the pigments used.

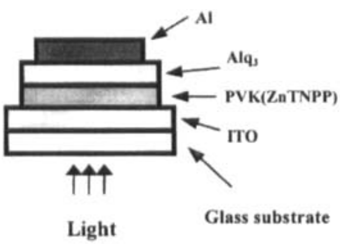

FIGURE 2 Schematic diagram of the p-n junction device.

Action spectra of the short-circuit photocurrent (J_{sc}) were measured by means of monochromatic light passed through a monochromator at a scan rate of 60 nm/min. The photoactive area was 0.19 cm^2.

TABLE I Photovoltaic Parameters Determined from the Analysis of J-V Characteristics under Illumination

Cells	V_{oc} (V)	J_{sc} (μAcm^{-2})	*FF*	η (%)
ITO/PVK(ZnTNPP)/Al (cell a)	0.40	0.47	0.28	0.16
ITO/PVK(ZnTNPP+Alq_3)/Al (cell b)	0.42	0.43	0.33	0.24
ITO/PVK(ZnTNPP)/Alq_3/Al (cell c)	0.94	0.62	0.21	0.48

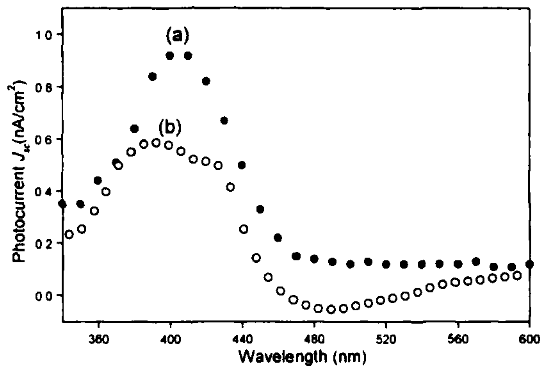

FIGURE 3 (a) The photocurrent spectrum (solid circle) and (b) the absorption spectrum (open circle) of ITO/PVK(ZnTNPP)/Alq_3/Al device.

RESULTS AND DISCUSSION

The configurations of the cells are schematically depicted in Figure 2. The photovoltaic parameters of the cells such as open circuit voltage (V_{oc}), short circuit current (J_{sc}), fill factor (*FF*) and conversion efficiency (η) were calculated from the analysis of *J-V* characteristics and summarized in Table 1.

Photocurrent action spectrum and absorption spectrum of ZnTNPP cell were depicted in Figure 3. In Soret band (420 nm) of porphyrin, higher photocurrent was obtained, which corresponds to higher carrier generation. Typical current-voltage (*J-V*) curves are shown in Figure 4. Open circuit voltages in 'cell a' and 'cell b' are almost consistent with the work function difference between Al (4.2 eV) and ITO (4.7 eV) electrodes. PVK film containing n-type semiconductor did not affect the enhancement of photocurrent because of less p-n junction effect in the cells. Higher conversion efficiency (0.48%) is also obtained in the 'cell c', which means that p-n junction effectively increases the extraction of the photoinduced electrons and holes from the depletion layer without recombination.

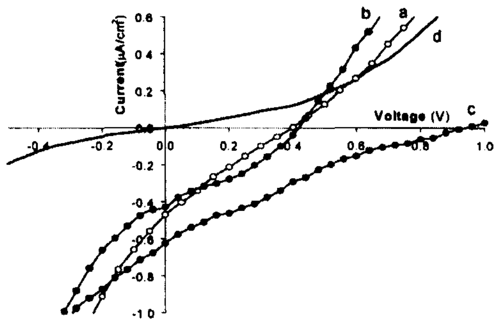

FIGURE 4 Current-voltage (J-V) characteristics of (a) ITO/PVK(ZnTNPP)/Al device, (b) ITO/PVK(ZnTNPP+Alq_3)/Al device, (c) ITO/PVK(ZnTNPP)/Alq_3/Al device under illumination and (d) ITO/PVK(ZnTNPP)/Alq_3/Al device in the dark.

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