

Fabrication and Evaluation of Organic Photoelectric Conversion Devices using Electrodeposited Polyaniline Films as a Hole Transporting Layer

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1. Introduction

Conjugated polymers are considerably attractive materials from the viewpoints of both scientific and practical applications. Polythiophenes, polyanilines, and polypyrroles are well-known examples of these polymers, which are used in the fabrication of organic transistors, organic solar cells, capacitors, and so on.

A combination of polythiophene and fullerene is considered to be good materials for the fabrication of organic solar cells because polythiophene typically works as a p-type semiconductor and fullerene is a n-type material. The practical solar cell applications of this combination have been investigated intensively.^{1, 2} The hole transporting layer is one of the important part to construct efficient organic photoelectric conversion devices. Polyethylenedioxythiophene doped with polystyrenesulfonate (PEDOT:PSS) is well known the hole transporting material.

To fabricate hole transporting layer, one of the general preparation methods is spin-coating. On the other hand, electrodeposition is also useful method for preparation of a hole transporting layer.³⁻⁵

We have developed organic photoelectric conversion devices using an electrodeposited conducting polymer.⁶⁻¹³ Recently, we have reported the effects of hole transporting layer on organic photovoltaic device consisting of electrodeposited polythiophene-porphyrin composite films.¹³

In this research, we will report the fabrication and evaluation of organic photoelectric conversion devices consisting of polythiophene-fullerene photoactive layer and electrodeposited polyaniline film as a hole transporting layer.

2. Experimental Procedure

All chemicals were used as received. The preparation route for organic photoelectric conversion devices is summarized in Fig. 1. First, aniline was electrodeposited on a cleaned indium-tin-oxide (ITO) transparent electrode in a three-electrode electrochemical cell containing aniline and diluted sulfuric acid. ITO was used as a working electrode, a platinum electrode as a counter electrode, and a Ag/AgCl electrode as a reference electrode. The applied potential to the working electrode was scanned between -1.0 and +1.5 V vs Ag/AgCl at a speed of 0.10 V/s for the cyclic voltammetry (CV) method of a potentiostat.

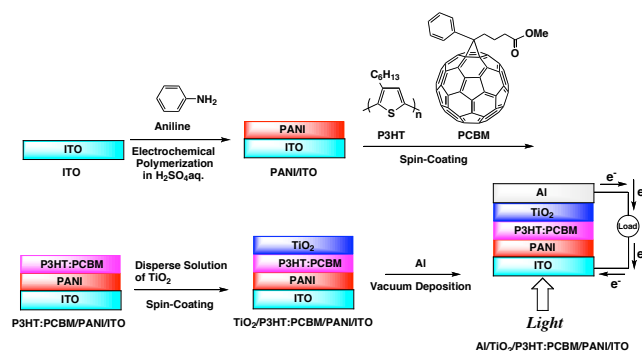


Fig. 1 Fabrication route for the organic photoelectric conversion devices.

During polymerization, the electrochemical cell was irradiated by ultrasonication. After polymerization, the working electrode was removed from the electrolyte solution, followed by rinsing with enough amount of water and drying in air to give polyaniline (PANI) film on the ITO electrode as: PANI/ITO. As a next step, chlorobenzene solution of [6,6]-phenyl C61-butyric acid methyl ester (PCBM) and regio-regular poly-3-hexylthiophene (P3HT) was spin-coated onto the PANI surface of PANI/ITO (P3HT:PCBM/PANI/ITO). Then, disperse solution of TiO₂ was spin-coated onto the P3HT:PCBM/PANI/ITO to obtain titanium oxide covered electrode (TiO₂/P3HT:PCBM/PANI/ITO). Finally, aluminum was deposited on the TiO₂ layer of the modified electrode using a vacuum evaporation, to obtained the organic photoelectric conversion device (Al/TiO₂/P3HT:PCBM/PANI/ITO). Electrode active area of the organic photoelectric conversion devices was 0.16 cm².

The current density-voltage (*J* - *V*) characteristics of the organic photoelectric conversion devices were measured by potentiogalvanostat under illumination at 100 mW cm⁻² (AM 1.5) using solar simulator. Light was irradiated from ITO side.

3. Results and Discussion

Electrochemically deposited polyaniline film (PANI) on ITO electrode was insoluble in the electrolyte solution and water. Fig. 2 shows SEM image of PANI/ITO. Actually, PANI/ITO showed a porous network structure. Thus, electric contact area between PANI and P3HT:PCBM

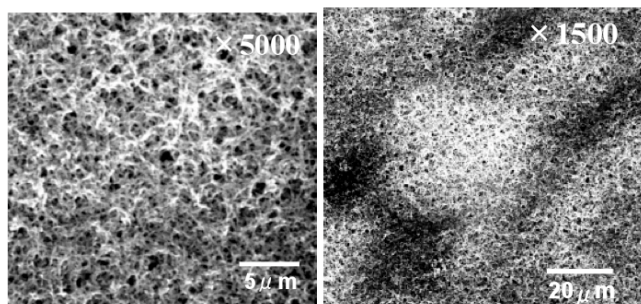


Fig. 2 SEM images of PANI/ITO.

photoactive layer become larger compared with that flat surface of the hole transporting layer which is prepared using spin-coating.

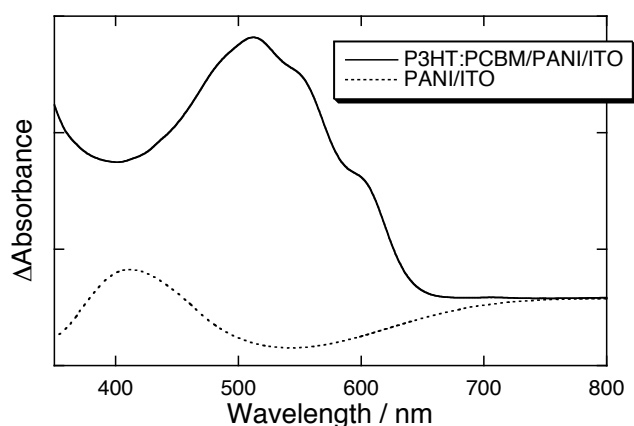


Fig. 3 Absorption Spectra of modified electrodes (normalized at 800 nm).

The absorption spectra of the modified electrodes, PANI/ITO, P3HT:PCBM/PANI/ITO are shown in Fig. 3. In both films, absorption band in near-infra-red wavelength region (longer than ~650 nm), which may be due to green colored-polyaniline film. The absorption profile of P3HT:PCBM/PANI/ITO shows obvious absorption band in 400 – 600 nm region due to polythiophene.

The organic photoelectric conversion device (Al/TiO₂/P3HT:PCBM/PANI/ITO) exhibited stable photoelectric response under irradiation of light (Fig. 4).

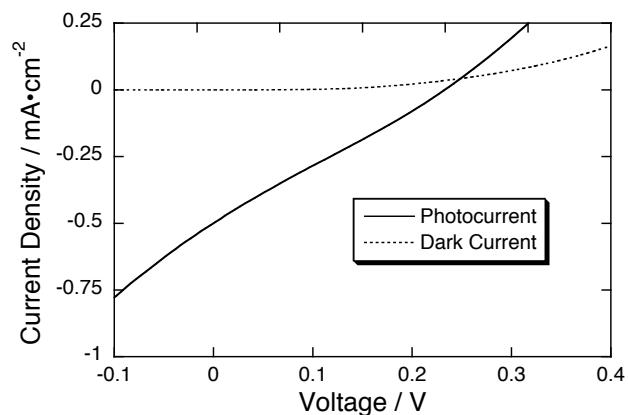


Fig. 4 J – V character of the photoelectric conversion device (Al/TiO₂/P3HT:PCBM/PANI/ITO)

These response may be due to photoinduced carrier generation in P3HT:PCBM photoactive layer. Detailed photoelectric conversion properties will be discussed in the presentation.

4. Conclusion

We have demonstrated that the preparation of the organic photoelectric conversion devices using the electrodeposited polyaniline as a hole transporting layer. Clear photoelectric conversion properties were observed. Experimental optimization and controlling of thickness of PANI layer are now in progress.

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