PREPARATION OF PROCESSABLE AND HIGHLY CONDUCTIVE POLYANILINE AND ITS APPLICATION AS A COUNTER ELECTRODE OF DYE SENSITIZED SOLAR CELL

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Introduction

In recent years, a dye-sensitized solar cell (DSSC) has been attracted a lot of attention because of high efficiency, simply manufacture and low cost. The DSSC generally consists of a nano structured TiO_2 photo electrode sensitized by a ruthenium complex dye, iodine-iodide electrolyte and sputtered Pt counter electrode[1]. Pt counter electrode is usually used in DSSC. However Pt is rare metal and very expensive materials. Other materials were expected to easily process and reduce the cost of manufacture. There are several alternative materials such as carbon electrode or conducting polymers[2,3].

Polyaniline (PANI) has good advantages due to high redox activity, simply synthesis process, environmental stability, and low cost. PANI is suitable material for counter electrode for DSSC. In this study, processable and highly conductive polyaniline was prepared[4] and applied to counter electrode of DSSC. PANI are expected to replace platinum counter electrode.

Experimental

Di-2-ethylhexylsulfosuccinate sodium salt (AOT) was dissolved in toluene under constant stirring at 0°C for 30min. To the clear solution, 140ml of hydrochloric acid (1M) was added and stirred for 1h and followed by addition of 15mmol of aniline and stirred for an extra hour at 0°C. Ammonium persulfate (APS, pre-cooled and dissolved in 20ml HCl) was added into the above milky mixture drop-wise for 2h and the mixture was further reacted for 24h. AOT–doped PANI showed good solubility for organic solvents such as toluene, chloroform, xylene and benzene. The change of conductivity with the amount of secondary dopant, m-cresol was investigated by preparing different weight ratio of PANI toluene solution to m-cresol. The conductivities of the films were measured using a four-probe method.

Fabrication of DSSC

TiO_2 was coated and sintered on FTO glasses. The fabricated TiO_2 was cut with $5mm^2$ and immersed into N3 dye in ethanol for 24 hours. After TiO_2 with N3 dye was dried at room temperature, TiO_2 photo electrode was fabricated. The electrolyte includes iodide ions and it was injected between photo electrode and counter electrode. The sandwiched DSSC was assembled. The xenon lamp and glass filter was used for measuring photon to current conversion efficiency and they prevent DSSC from absorbing incident photon with under 350nm. The light intensity was adjusted by silicon type photo diode.

Results and Discussion

Preparation of processable and highly conducting polyaniline was carried out in the presence of anionic surfactant AOT in toluene and aqueous hydrochloric acid emulsion system. AOT doped polyaniline showed solubility in toluene and highly conductivity after secondary doped with m-cresol. The secondary doping induces polymer backbone conformation from "folded coil-like" to "expanded coil-like" and the highest conductivity obtained[4].

Polyaniline electrode catalyzes the reduction reaction with iodine ion and having high conductivity. The reduction reaction between iodine and counter electrode in iodine liquid electrolyte was measured by cyclic voltammetry (CV). The iodine liquid electrolyte was consisted of iodine, lithium perchlorate and acetonitrile.

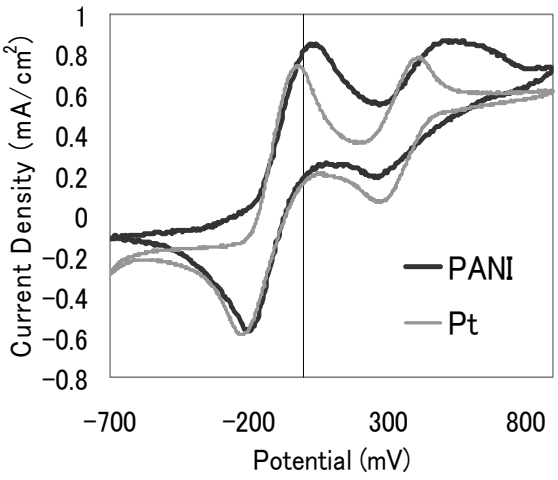

Figure 1. Cyclic voltammogram for Pt and PANI electrode

Table 1. Photovoltaic performance of DSSCs with various PANI and Pt counter electrode

Counter Electrode	Jsc[mA/cm^2]	Voc[mV]	F.F. [%]	η[%]
ES	16.0	560	42.4	3.8
EB	16.3	570	47.4	4.4
re-ES	14.6	520	53.0	4.0
Pt	16.0	610	42.0	4.1

Reference electrode and counter electrode were Ag/Ag^+ and Pt, respectively. The CV of Pt and PANI counter electrodes were indicated in Fig.1. Table 1 shows the photovoltaic performance of DSSCs with various PANI electrodes, Emeraldine Salt(ES),Emeraldine Base(EB),re-doped Emeraldine Salt(re-ES) and Pt counter electrode.

The redox reaction of iodine ion with counter electrode was given to the following scheme.

$I_3^- + 2e^- \rightarrow 3I^-$ (oxidative reaction)

$2\ I_3^- \rightarrow 3I^- + 2e^-$ (reductive reaction)

The important reaction for counter electrode in DSSC is reduction reaction between counter electrode and iodine electrolyte. This reduction reaction is applied to first oxidation peak on CV. It is commonly considered that less the values of first oxidation peak on voltage promote oxidative reaction. The PANI electrode has high photovoltaic efficiency and low oxidative potential similar to Pt. The overall energy conversion efficiency of the DSSC with EB counter electrode is higher efficiency than that of the DSSC with Pt counter electrode. This is due to the fact that iodide ion in electrolyte was doped into PANI electrode during measurement of photovoltaic efficiency.

References

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