Enhanced efficiency of dye-sensitized solar cells using TiO_2-tourmaline composites photoanode

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Abstract

We successfully fabricated the TiO_2-based photoelectrodes composited with Tourmaline powder to improve the power conversion efficiency of dye-sensitized solar cells (DSSCs). The TiO_2-Tourmaline composite electrode has been prepared by a direct mixing method. The ratio of Tourmaline powder was 1~5wt%. The composited electrodes were immersed in 0.5mM N719 solution in ethanol for 24 h. The results show that the DSSCs incorporation with 3wt% tourmaline powder in TiO_2 photoelectrode was enhanced up to 10% compared with the pristine TiO_2 photoelectrode. The TiO_2-tourmaline composite electrodes at 3wt% ratio contributed to reducing the resistances of the surface and the interface of the photoelectrode. The internal resistances of the photoelectrode directly affect the power conversion efficiency. We investigated diffusion coefficient (D_n), diffusion length (L_n), recombination life time (τ_r) from the observation of intensity modulated photocurrent spectroscopy (IMPS) and intensity modulated photovoltage spectroscopy (IMVS) and other characterized by X-ray diffraction (XRD), electrochemical impedance Spectroscopy (EIS) and solar simulator system.

Results and Discussion

Figure 1 shows the photocurrent density (J_{sc}) versus photovoltage (V_{oc}) characteristics of the DSSCs. The photo electrochemical performance was measured by calculating the energy conversion efficiency (η). The best conversion efficiency was 4% for the TiO_2-Tourmaline composite electrode(3wt%), with a short circuit current density(J_{sc}) of 8.5mA/cm^2, an open circuit voltage(V_{oc}) of 0.72V, and a fill factor(FF) of 0.66. The pristine TiO_2 device efficiencies were 3.6%. The open circuit voltage changed slightly with the insertion of Tourmaline particles, from 0.68V to 0.72 V, while the fill factor changed with the insertion from 0.64 to 0.67, and the short circuit current changed from 7.82 mA/cm^2 to 8.5 mA/cm^2. For pristine TiO_2, the efficiency (η) was 3.6%, which increased to 4.0% for 3wt% tourmaline particles added to TiO_2. The effect of different ratios of tourmaline powder added to the TiO_2 was also investigated. 3wt% was the optimum ratio. When the tourmaline powder was added, the number of photons increased, and hence increased the probability of photon and dye molecule interactions. Our results suggest that the insertion of tourmaline powder provides optimal electron paths by reducing the surface and interface resistance, by changing the surface morphology of the electrode.

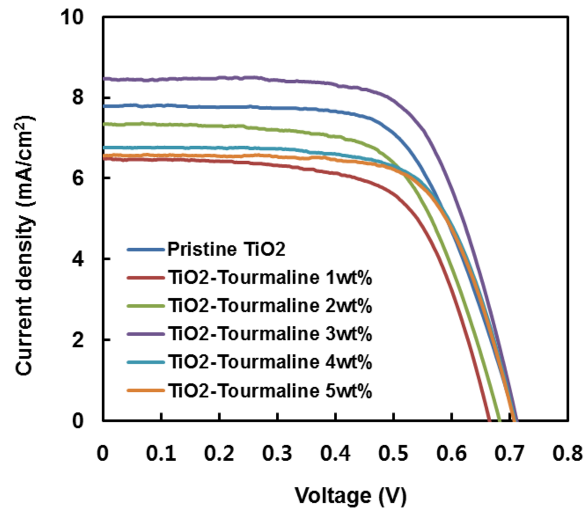

Fig.1 *J-V* curves of the analyzed DSSCs using different anode electrodes.

Table.1 Photovoltaic performance of the DSSCs with photoanodes containing various percentages of tourmaline[a]

	V_{oc} (V)	J_{sc} (mA/cm^2)	FF	η (%)
Pristine TiO_2	0.71	7.82	0.64	3.6
1wt%	0.68	6.50	0.64	2.8
2wt%	0.70	7.37	0.62	3.2
3wt%	0.72	8.50	0.66	4.0
4wt%	0.72	6.77	0.67	3.2
5wt%	0.72	6.59	0.67	3.2

[a] mesasured with effective incident area of 0.25 cm^2 under AM 1.5 100 mW/cm^2 simulated sunlight irradiation.

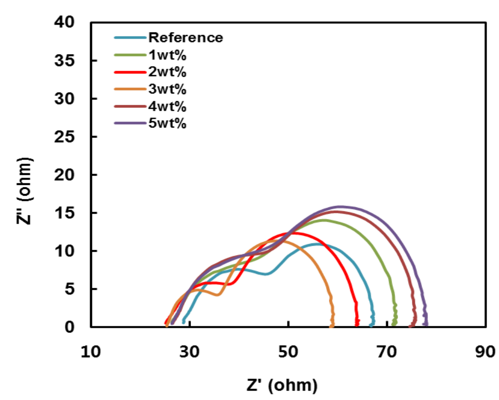

Fig. 2 The Nyquist plot of the impedance characteristics between Z_{re} and Z_{im} with the angular frequency ($\omega=2\pi f$) of photoelectrode containing various percentages of tourmaline.

Reference

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Acknowledgments

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