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Electrical Generation of Dye-Sensitized Solar Cells Using Sensitizer from Rose Flower

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Abstract. Dye-sensitized solar cell (DSSC) is part of the thin film family that consists of a TiO2 electrode coating which acts as a photo electrode, sensitizer from dye molecules soaked in the TiO2 film, electrolyte layer and a counter electrode. This paper focuses on the usage of a sensitizer from the rose flower and will review some of the research conducted on dye sensitizers from other researcher. Rose flower also known as woody perennial of the genus Rosa, within the family Rosaceae is extracted and were used as sensitizer to fabricate dye sensitized solar cell (DSSC). The photoelectrochemical performance of Rose sensitized solar cell shows parameter of open circuit voltage, $V_{OC,}$ short circuit current, (I_{SC}), fill factor (FF), solar cell efficiency (η), and peak absorbance rate as much as 0.13 V, 57.58 µA, 0.58, 0.85% and 3.5 at 550nm respectively. The photoelectrochemical performance of DSSC and the usage of natural sensitizer from Rose flower dye demonstrate good potential to be applied as a sensitizer yet detail investigations are essential in terms of its applicability for long term application.

Introduction

Dye sensitized solar cells (DSSC) is a devices which convert visible light into electricity based on sensitization of wide band-gap semiconductor [1]. Titanium dioxide, TiO_2 (anatase) is used as semiconductor material in DSSC because of its stability and nontoxic characteristic which also has high transmittance in visible spectrum. Anatase phase of TiO_2 contained high photocatalytic properties and wide direct bandgap [2]. Natural dye from fruit and plant are investigated in terms of dye sensitizers as an alternative to chemical dyes which is expensive and also hard to synthesize.

Dye Sensitizer

Sensitizers are used to absorb sun light and the electrolyte which contains the iodide/tri-iodide redox-couple provides electrons flow in the oxidised sensitizer [3]. Sensitization allows electrical generation with the energy level of irradiation lower than the bandgap of semiconductor in which light attracting dye molecules are adsorbed [4]. DSSC uses synthetic dye from ruthenium complex together with the wide band gap semiconductors oxides but the limitation is due to its costly and complicated preparation. The complexes also contain heavy metal end product which could pollute the environmental [5]. This resolves to the usage of natural dyes which are cheap, renewable, non-carcinogenic, and non-toxic [6]. Natural dyes are also abundant, easily extracted and safe materials [7].

Review on Organic Dye Sensitizer

Fruits, leaves and flowers often display various colours in the form of pigments that can be extracted and use as a dye in DSSC. Most green plants are rich with chlorophyll and Anthocyanin pigments which is an important component that gives colours to a plant or fruit [8]. Anthocyanins are natural components that mostly give red–purple coloration to fruits and plants, and they have light absorb in the range of 520–550 nm wavelengths [9]. Natural dyes play a key role in harvesting sunlight and transferring solar energy into electric energy [10]. H. Chang et al. used spinach extract as a sensitizer and has manage to produce a conversion efficiency of about 0.131% which is lower compared to ipomea which has an efficiency of 0.278% [11]. H. Chang et al. also discovered that by using pomegranate leaves and mulberry fruit as natural dyes, the conversion efficiencies are 0.597% and 0.548% respectively [8]. En Mei Jin et al. uses wormwood plant as sensitizer which has an efficiency of 0.9% compared to bamboo which only has 0.7% and maple that is 0.4% [12] while Ho Chang et al. utilized the purple cabbage as sensitizer which manage to achieved up to 0.75% of efficiency [13]. A. I. Babatunde et al. investigated the Lonchocarpus cyanescens as natural sensitizer and produced conversion efficiency of 0.37% [14]. S. Tekerek et al. discovered by using Black Carrot as natural dye, the efficiency is 0.25% higher than Rosella and Black Rasberry which is only 0.16% [15]. M. Tripathi et al. used Punica granatum as natural sensitizer, and the performance of conversion efficiency shows value more than 1 % to 1.86% compared to chlorophyll, bixin, and anthocyanin [16]. G. Calogero et al. showed when using wild Sicilian prickly pear, the conversion efficiency is 1.26% much lower compared to red turnip is 1.7% [17]. A. R. Hernandez-Martinez et al. investigated that by using purified Bougainvillea Glabra, a conversion efficiency as much as 0.49% is achieve compared to Violet Bougainvillea spectabilis which has only 0.35% [18]. B. K. S. Perera et al. testified that by using natural pigment extracted from Nilkatarolu Flowers displays a conversion efficiency of 0.06% [19]. M. I. Kimpa et al. discovered in their experiment, when using Pawpaw Leaf and Flame Tree Flower as sensitizer, the conversion efficiency shows that the conversion efficiency is 0.20% for both natural dyes [20]. Hee-Je Kim et al. reported by using Curcumin Dye as natural sensitizer, the conversion efficiency is achieved to 0.36% [21]. G.R.A Kumara et al. found that by using Shisho leaf pigments, an energy conversion efficiency of 1.3% is achieved [22]. M. S. Roy et al. reported Rose Bengal dye resulting conversion efficiency of 2.09% [23]. K. V. Hemalatha et al. reported carotenoid and anthocyanin were extracted from Kerria japonica and Rosa chinensis showed the result of conversion efficiency are about 0.22% and 0.29% [24].

DSSC Setup and Measurements

The fabrication of DSSC has been explained detail in [25] as well as the test involved. The absorption spectra were performed by Evolution 201 UV-Vis spectrophotometer. The light source is conducted by using halogen lamp produced about 512 W/m^2. The parameters of solar cell are measured using Data Logger (Graphtec) and Multi meter. The indoor testing is covered by using black box during measurement process to prevent the influence of room temperature that will affect the reading of DSSC in terms of charge generation.

Absorption spectra of Rose syrup's dye

Absorption spectra present the absorption transition between the dye ground state and excited states and the solar energy range absorbed by the dye [8]. The absorption range of Rose's dye was taken from 400-700 nm which the absorption peak at 550 nm shown in Fig. 4. The presence of anthocyanins pigments from alcoholic bound protons will condense with hydroxyl groups that appear on the surface of TiO_2 film. Their binding will stabilizes the excited state and shift towards lower energy of absorption maximum. Anthocyanins are capable to be chemically absorbed into TiO_2 and sensitized to visible spectrum.

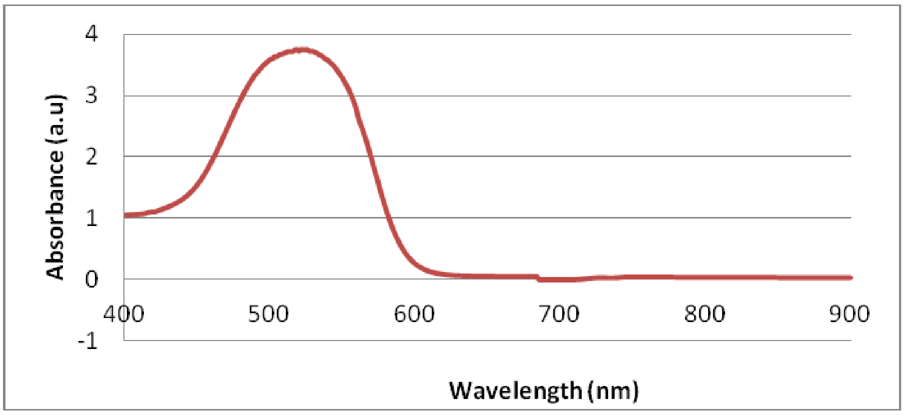

Fig. 4 The absorption spectra of Rose's dye

Table 1 lists the conversion efficiencies of the fabricated DSSC using Rose's dye extracted from Rose petal. The open circuit voltage (V_{oc}), short circuit current (I_{sc}), Fill Factor (FF) and efficiency (η) were 0.13 V, 57.58 mA/cm^{-2}, 0.58% and 0.85% respectively. The extract of Rose's dye acts as a good sensitizer and efficiently promotes electron transfer across the dye/semiconductor interface. Fig. 5 had shown the current-voltage for curve for DSSC using Rose's dye.

Table 1: Photoelectrochemical parameters of DSSC

Coating thickness (μm)	Dyes	Open Circuit Voltage, V_{oc} (V)	Short Circuit Current, I_{sc} (mA)	Solar Irradiance W/m^2	Fill Factor, FF (%)	Efficiency, η (%)
30	Rose Extract	0.13	57.58	512	0.58	0.85

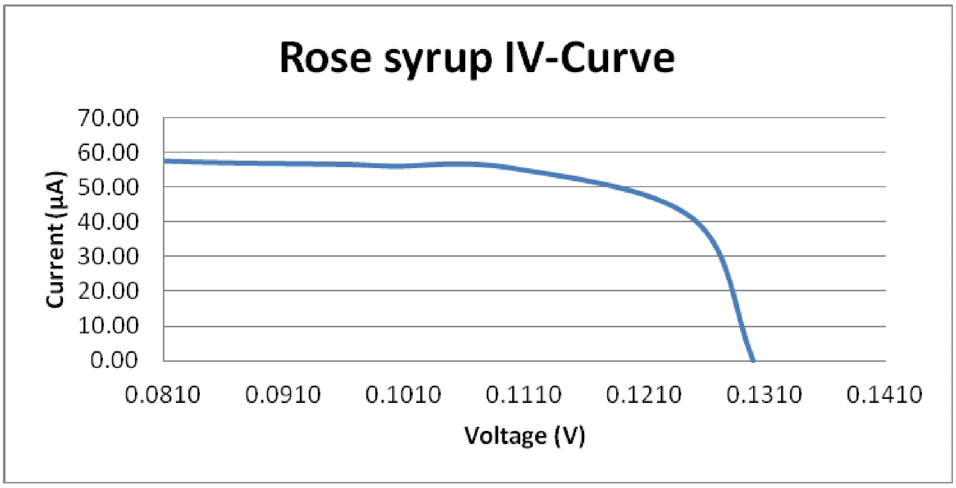

Fig. 5 Current-voltage for curve for DSSC using Rose's dye.

Conclusion

Successful conversion of visible light into electricity was achieved by using Rose's dye as dye sensitizer in DSSC. The use of natural dye as dye sensitizer is good because of easily purification, simple extraction and low cost but only selected dyes promotes energy conversion. Result shows much potential from the Rose flower to use as a sensitizer.

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