USE OF SOME SRI LANKAN PLANT PIGMENTS EXTRACTED FROM BARKS AS THE SENSITIZER IN DEY-SENSITIZED SOLAR CELLS

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Introduction

Sensitization of wide band gap semiconductors using dyes has a long history, dating back to early days of photography of the 19th century. But the most well known and most studied unconventional photovoltaic system is the dye sensitized nano-structured solar cell developed by Gratzel in 1991 [O'Regan, *et al.*, 1991]. Sensitizer or the dye is the photoactive element in the dye-sensitized solar cell (DSC) and it plays the role of harvesting photons of the incoming radiation. When selecting a sensitizer for use in a DSC, factors such as absorption of the solar radiation, extinction coefficient, exited state lifetime, energy level alignment, functional groups to form bonds with semiconductor surface and stability are considered. Uses of various types of dyes and pigments including organic dyes, organic metal complexes and natural pigments (extracted from pomegranate, grapes, black berries etc.) have been reported in the past few years. Anthocyanin extracted from different natural sources has already been used as a photon harvesting material in dye-sensitized solar cells [O'Regan, *et al.*, 1991; Jayaweera, *et al.*, 2001; Samaraweera, *et al.*, 2007]. The efficiency of a typical solar cell, fabricated using anthocyanin-based pigments is about 1 % [Fernando, *et al.*, 2008]. Further, the stability of these natural pigments is considerably low and it is a major drawback in commercial applications. In this work, pigments containing anthocyanin extracted from barks of some Sri Lankan trees were studied in order to investigate the their photovoltaic characteristics and stability.

Materials and Methods

The natural pigments from the barks of the trees *Halamba* (*Lasianthus varians*), *Palu* (*Manilkara hexandra*), *Hulanhik* (*Chukrasia tabularis*) and *Katakala* (*Bridelia retusa*) were extracted as follows. Bark of the tree was cut into very small pieces and was collected in a beaker. Then 15 ml methanol was added and mixed well. The mixture was kept for about 12 h in darkness at room temperature until the dye gets extracted. Subsequently the mixture was filtered and the pigment was separated.The extracted pigments were characterized using UV-Visible absorption spectra, cyclic Voltammetry and Mott-Schottky plots using that have been reported in the literature [Premaratne, *et al.*, 2008]. A gel consisting of I_2/I_3^- redox couple was used as the electrolyte [Ileperuma, *et al.*, 2002]. DSC devices of the type FTO/TiO_2/pigment/gel/Pt were fabricated using the extracted pigments as the sensitizer. The DSCs were characterized by measuring the

V_{OC} and I_{SC} using a calibrated Kodak light source of intensity 1000 Wm^{-2}.

Results and Discussion

Absorption spectra for pigments extracted from *Helamba*, *Palu*, *Ketakala*, and *Hulanhik* are illustrated in Figure 1. All pigments exhibit considerable light absorption in the visible region of the solar spectrum for using as the sensitizer in DSC devices. The effective band-gaps for the pigments extracted from *Helamba*, *Palu*, *Hulanhik* and *Ketakala* estimated using the prominent onsets of the UV-Visible absorption spectra were found to be 2.40 eV, 2.21 eV, 2.09 eV, and 2.12 eV respectively.Mott-Schottky plots of the pigments show a negative gradient indicating that the pigments behave as p-type materials. HOMO and LUMO energy levels for the pigments were calculated for two samples by means of cyclic voltammetry curves and UV-Visible spectra [Table 1].

Table 1. Calculated HOMO and LUMO energy levels of the pigments Halamba and Palu

Pigment	HOMO / eV	LUMO / eV
Halamba	4.62	2.22
Palu	4.69	2.48

I-V characteristics for the fabricated DSC devices are tabulated in Table 2 and the maximum efficiency of about 1.5 % was observed for the DSC sensitized using *Palu* pigment in acidic medium. Stability studies of the fabricated devices show that the pigments extracted from barks of the *Halamba* and *Palu* trees are relatively more stable than the pigments extracted from seeds and flowers of some plants [Premaratne, *et al.*, 2008].

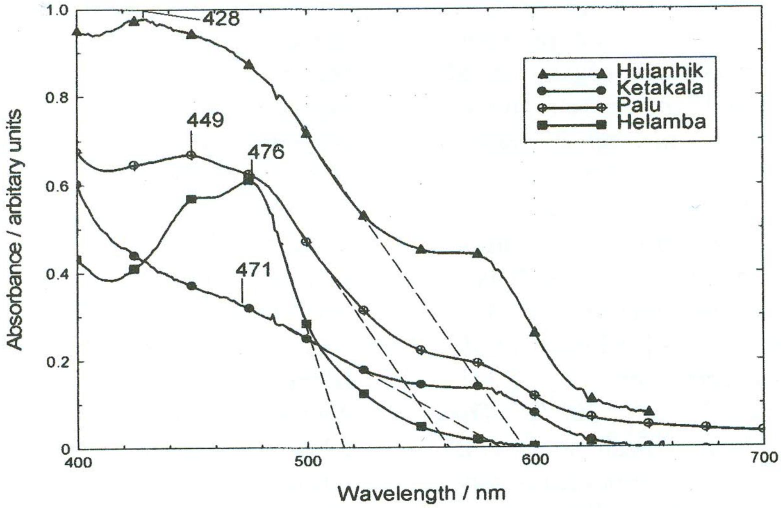

Figure 1. UV-Visible absorption spectra for Helamba, Palu, Hulanhik, Ketakala pigments

Table 2. I-V Characteristics parameters evaluated for dye sensitized solar cells

Pigment		V_{oc}/V	I_{sc}/μA	J_{sc}/mAcm^{-2}	Fill Factor %	Efficiency %
	Acidic	0.456	858	7.15	48	1.59
	Neutral	0.543	458	3.82	41	0.85
Helamba	Basic	0.655	228	1.90	57	0.72
	Acidic	0.539	713	5.94	50	1.60
	Neutral	0.568	318	2.65	54	0.81
Palu	Basic	0.717	190	1.58	58	0.65
	Acidic	0.491	480	4.00	30	0.59
	Neutral	0.506	220	1.83	50	0.46
Ketakala	Basic	0.618	100	0.83	47	0.24
	Acidic	0.482	463	3.86	37	0.69
	Neutral	0.523	224	1.86	48	0.48
Hulanhik	Basic	0.530	81	0.68	47	0.17

Conclusions

The natural pigments extracted from the barks of *Halamba* and *Palu* show reasonable absorption of visible light in the range 400 nm to 700 nm in methanol. The alignment of the energy levels of the pigments is also suitable for them to be used in DSC devices. The attachment of the dye to TiO_2 is reasonably good and pigments show p-type behavior. Even though the fabrication of the device is quite simple and of low cost the efficiency of these devices are somewhat low compared other types of photovoltaic devices reported in literature.

References

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