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PRELIMINARY STUDY OF CURCUMIN DYE-SENSITIZED SOLAR CELLS FOR THE WAVELENGHT-SELECTIVE GREENHOUSE

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Abstract

The depletion of reserves of fossil energy sources makes humans look for new and renewable energy sources. Dye Sensitized Solar Cell (DSSC) is now a very potential alternavtive to be used as renewable energy source. One of the most promising factors of this DSSC is the relatively cheap manufacturing cost, considering that cost is the biggest barrier factor for commercialization of conventional Silicon based solar cells [1]. DSSC remain very attractive to the researchers due to their easy preparation methodology, lower toxicity, ecofriendly, abundance of sources and ease of production. Natural dyes are a very good alternative for their use as sensitizers for solar cells, the only disadvantage being the its low power conversion efficiency compared to other conventional cells.

Curcumin is a powerful coloring agent widely used in the food industry, being the principal curcuminoid of the turmeric *Curcuma Longa*, a member of the ginger family (*Zingiberaceae*). Curcuminoids are responsible for the bright yellow color of the plant's rhizomes. Three different curcuminoids can be found in *C. Longa*: curcumin, demethoxycurcumin and bisdemethoxycurcumin [2].

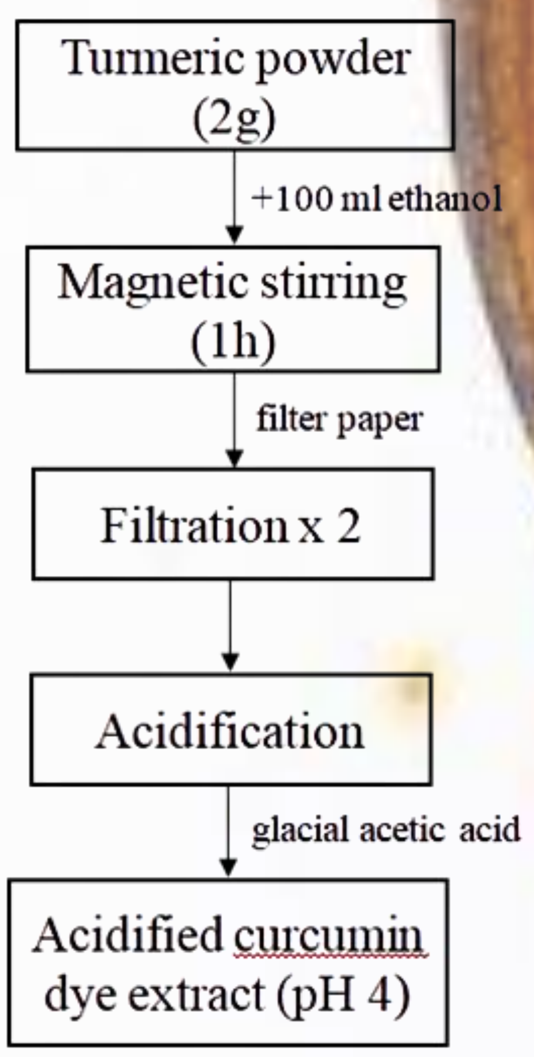
The low efficiency of DSSC should be overcome mainly by improving the binding of natural dyes with TiO_2 film at 550°C of the calcination temperature, also by treating these films with a solution of $TiCl_4$ can improve the power conversion efficiency (PCE). In this study, curcumin was extracted from turmeric powder in ethanol and the extracts were then acidified with glacial acetic acid. By calcination of the TiO_2 anode at 500 and 550°C, respectively, it was proved that the treatment with $TiCl_4$ solution is beneficial.

Aims

- the improvement of the natural DSSCs;
- the improvement of power conversion efficiency (PCE) by treating the photoanodes with $TiCl_4$ solution at a high calcination temperature 550 °C;
- the improvement immobilization of the adsorbent natural dye molecules onto the TiO_2 surface through the acidifing with glacial acetic acid;
- improving the binding of natural dyes with TiO_2 film

Methods and Results

Curcumin dye preparation:



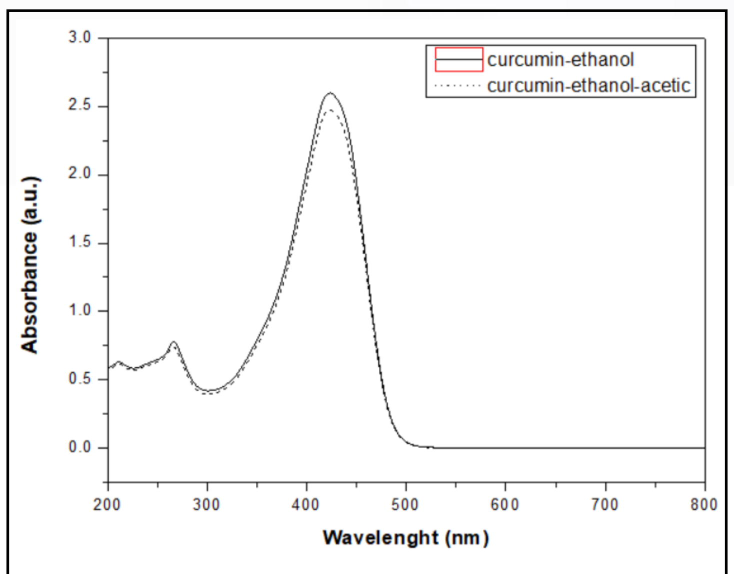


Figure 1. UV-Vis spectrum of curcumin extract using a) ethanol; b) ethanol acidified with acetic acid

Preparation of DSSCs:

TiO_2 photoanode

- By depositing a thin film of mesoporous TiO_2 paste on the conductive side of a fluorine-doped tin oxide (FTO) glass by the doctor-blade technique the working electrode (photoanode) was prepared. Then follows the calcination of 2 films at 500°C respectively of the other 2films remaining at 550°C, each for 1hour at 1 degree/min.
- 2 films of the TiO_2 coated FTO glass was subsequently dipped in diluted $TiCl_4$ solution for 1 hour at 70 °C and annealed at 450°C for 60 minutes. The other 2 films were not treated with $TiCl_4$ to study the improvement of PCE.
- After, the films were immersed in the natural dye under dark, at refrigerator for 5h.

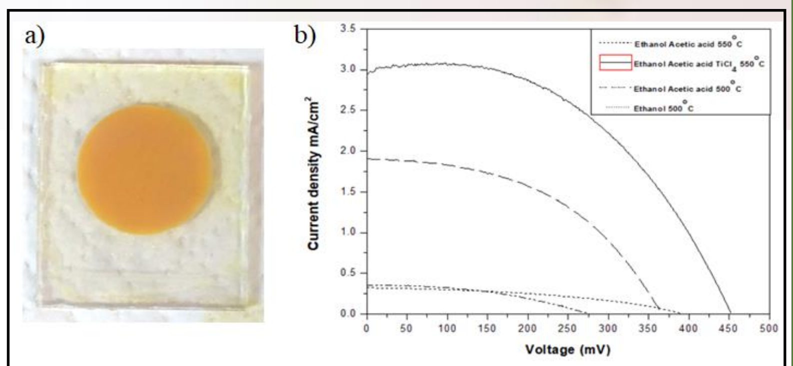


Figure 2. (a) Image of TiO_2 film sensitized with curcumin dye; (b) J-V curves of the n-type DSSC based on curcumin dye at calcination temperatures of 500 and 550°C respectively

Methods and Results

Platinum counter electrode

Catalytic counter electrodes were obtained by the thermal decomposition of the H_2PtCl_6 solution on FTO-coated glass at 400 °C for 30 min.

Redox electrolyte

In order to obtain the I^-/I_3^- electrolyte solution 0.5 M KI, 0.03 M I_2 were added in ethylene glycol and acetonitrile with a volume ratio of 4:1.

DSSC assembling

In order to fix together the TiO_2 photoanode with the platinized counter electrodes, a 60 µm thick spacer Meltonix 1170-60 was used. The electrolyte is injected into the space between the electrodes.

A Keithley 2450 SourceMeter SMU Instruments was used to measure the solar cell performances under AM 1.5G simulated sunlight (1000 W/m²).

Table 1. Photoelectrochemical parameters of DSSCs based on natural dye sensitizers, adsorbed on TiO_2

Name	J_{SC} [mA/cm²]	V_{OC} [V]	FF [%]	PCE [%]
Ethanol acetic $TiCl_4$ 550°C	**2.95**	**0.453**	**50.3**	**0.685**
Ethanol acetic 550°C	1.9	0.367	47.6	0.338
Ethanol acetic 500°C	0.35	0.276	41.5	0.041
Ethanol 500°C	0.32	0.393	43.4	0.056

Figure 3. DSSC assembling

Conclusions

Our work studied the effect of calcination temperature on the photovoltaic performance of curcumin-sensitized solar cells. A 50°C increase in the calcination temperature resulted in an increase in PCE from 0.041% to 0.388%. Furthermore, $TiCl_4$ treatment of the photoanode doubled the PCE of curcumin-DSSC. The best PCE was obtained for the photoanode prepared at 550 ° C after treatment with $TiCl_4$.

In conclusion, the selective absorption of UV, the radiation harmful to plant DNA, as well as preserving transparent Photosynthetic Active Radiation, the light of wavelength between 430 and 700 nm (PAR), imposed by the grown of the plants in the greenhouse, have shown experimentally that curcumim-DSSC could be an inexpensive concept for the integration of photovoltaics panels in the greenhouse, as agricoltaic system.

Acknowledgement

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References

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