Novel Solid State Solar Cell Made from n-Cu_2O Using One Step Pyrolysis Coconut Shell Powder Activated Carbon as Upper - Electrode

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Abstract: Coconut trees are distributed throughout many parts of the world, normally in the Asia-Pacific and South Asian region. It grows primarily in tropical and coastal areas. Activated carbon was prepared by one step pyrolysis by treating with 0.1 M KOH of scoured coconut shell ball billed micro particles at 364 °C heat rate of 10 cm^{-1} in the nitrogen atmosphere for 0.15 h then washed with HCl. Iodine number was determined to all dried activated carbon samples. Powder activated carbon was characterized with SEM and proximate analysis. The copper plate was fabricated by using a thin film of Cu_2O which is formed by boiling ($5*10^{-3}$ M) solution of copper sulphate for 60 min. After a solid state photovoltaic cell Cu/n-Cu_2O/CAC/ITO were produced have CAC acts as the upper electrode of the solid state solar cells. It was formed that n-Cu_2O/CAC contact forme schottky barrier junction to separate photo generated charge carriers, forming a solid state photovoltaic device. UV Absorption spectra, FTIR spectra. V-I characteristics and photocurrent development with time were used to compare photovoltaic characteristics of solid state thin film solar cell from this work.

Keywords: Ball mill, Coconut shell, One step pyrolysis, Thin film solar cell.

I. Introduction

Coconuts are broadly distributed throughout many parts of the world, especially in the Asia-Pacific and South Asian region. It grows primarily in tropical and coastal areas [1-2]. Coconut shell ideal raw material for activated activation production. Chemical activation can be done low temperature.

Coconut shell activated carbon has contained meso pores and functional groups on surface structure, ability it excellent for adsorption [3]. Carbon materials have been recently used as electrode substrates to make different electrodes devices [4-5]. Cu_2O best and low cost raw material for preparing n-type semi-conductor [6]. Layer of Cu_2O can be easily make in using purify Cu plate immerse in $CuSO_4$ (aq) solution, when changing in heat parameters of $CuSO_4$ (aq) solution [7-8]. This research work reports the findings of the development of a solid state thin film solar cell, based on activated carbon derived from lingo-cellulosic Material (Coconut shell), which act as an upper electrode on the n-Cu_2O. In this work, Potassium Hydroxide (KOH) chemical activation one step pyrolysis methods were used to activate the raw coconut shell. Diffused reflectance spectra, FTIR spectra. V-I characteristics and the photocurrent stability of the cell were measured to compare the effectiveness of the solid state thin film solar cells, based on activated carbon derived from Coconut shell.

II. Methodology

A. Materials

Coconut shell was collected from a coastal area in Sri Lanka. The sample were break into small parts, then soaked soap flacks tank for 20 min, after soaking and washed with hot water, finally dried in muffle oven at 105 °C for 6 h.

B. Methods

Activated carbon were prepared by one step pyrolysis by chemical treatment with 0.1 M of Potassium Hydroxide (KOH) of purify coconut shell particles at 364 °C heat rate of 10 °C min^{-1} in nitrogen atmosphere for 0.15 h after wash with 0.01 M HCl for 1 hour. Before pyrolysis coconut shell were scoured (alkaline-bio) thoroughly and ultrasonically wash with distill water to remove unwanted chemical and dried at 80 °C in electrical muffle oven for 5 h. Raw coconut shell micro range particles were prepared by using ball mill machine. It driven at (400-500) rpm for 10 minutes. Coconut shell particles were leach with 0.5 M KOH for 1 hrs. After coconut pulp were filtered and separated.

C. Production Step of Cu/n-Cu_2O/CAC/ITO and Cu/n-Cu_2O/CAC/ITO Photo Electrode

Manually well clean purity Copper plate (1 x 4 cm^2) was immersed in (5×10^{-3} M) $CuSO_4$ solution at 540 °C for 60 min. After boiling, a layer of Cu_2O formed on the copper plate.

Cu/n-Cu_2O photo electrode were washed with pure distilled water and dried and were stored in vacuumed dedicator.

After fabricating Cu/n-Cu_2O a thin film layer, coconut shell active carbon (CAC) were add on Surface Cu/n-Cu_2O to form Cu/n-Cu_2O/CAC/ITO solid state photovoltaic cell, by placing ITO conductive glass plate on Cu/n-Cu_2O/CAC as Fig. 1.

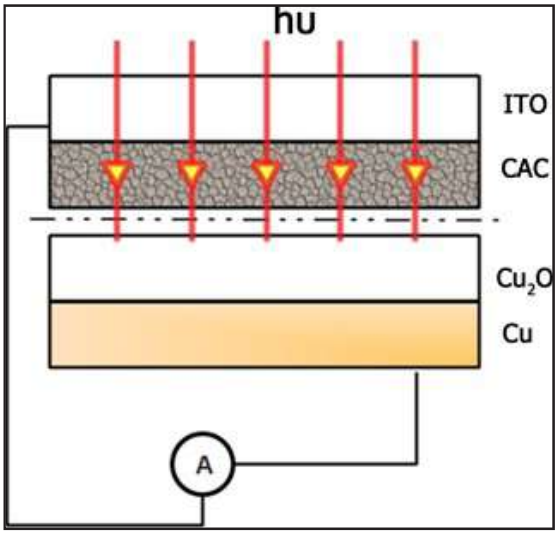

Fig. 1: Schematic Presentation of the Thin Film Photovoltaic Device Structure: Cu/n-Cu_2O/CAC/ITO

D. Experimental Techniques

Coconut shell was grounded by using ball mill machine (Model: Fritsch supreme line Pulverisette 7). Ultra-sonic heat Barth was used to coconut shell powder cavitation process. (Model: Rocker Soner 203 H). Absorption properties were determined by Shimadzu 1800 UV Spectrophotometer. FTIR Spectra was analysis by Shimadzu IRAffinity-1S FTIR Spectrophotometer and Potassium Bromide (KBr) pellet. A 100 W tungsten filament lamp and water circulated Perspex cell was used to cut off the IR radiation of the tungsten lamp.

III. Results and Discussion

A. Characterization of BPAC

Fig. 2 shows SEM micrograph of after chemical activation of Coconut Shell Activation (CAC), though the micrograph honeycomb like a porous surface activated carbon could be seen, on this fact, it can be concluded that CAC presents the sufficient adsorbing morphology characteristics were developed for sample washed with acid.

EDS results show that element content of activated carbon structure. Carbon content is about 99 %. Proximate analysis carried out for find the ash content of activated carbon. This value is very close to commercial activated carbon. It reviles that high absorbance capability of CAC.

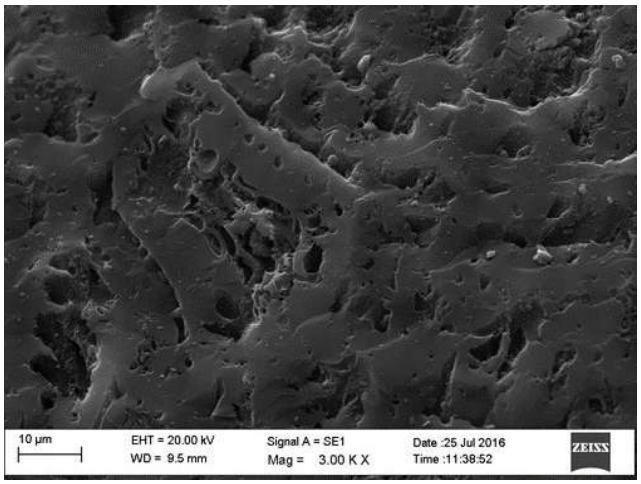

Fig. 2: Micrograph of Surface of Coconut Shell Activated Carbon by One Step Pyrolysis

B. Fourier-Transform Infrared (FTIR) Spectroscopy of Cu/n-Cu_2O

Fig. 3 shows the FTIR spectrum of surface of Cu_2O layer on copper plate by boiling time for 60 min copper sulphate solution. As shown in Fig. 3, displays an absorption peak at around 630.72 cm^{-1}, which can be attributed to the Cu(I)-O vibration. The present FTIR spectrum is well consistent with that of Cu_2O. In its crystal lattice, Cu_2O is connected to two oxygen atoms in a linear coordination, this was clearly seen in FTIR spectroscopy.

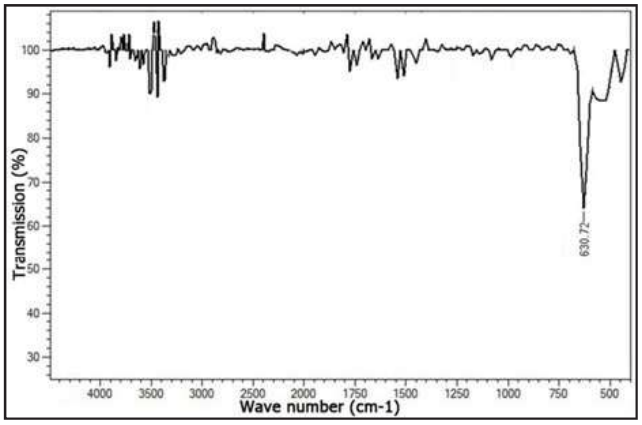

Fig. 3: Shows the FTIR Spectrum of Surface of Cu_2O layer

C. Diffuse Reflectance Spectra

Fig. 4 shows the diffused reflectance spectra of two examined samples. The shapes of the graph are found to be interrelated to each other. Curve (C1) of Fig. 4 shows the diffuse reflectance spectra of the Cu/n-Cu_2O/ITO photo electrode. Adsorption edge corresponding to light adsorption of n-Cu_2O ($\lambda \approx 620$ nm band gap = 1.9 ev). Curve (C2) of Fig. 4 shows the diffuse reflectance spectra of Cu/n-Cu_2O/CAC/ITO. Coconut shell

activated carbon spread successfully on Cu_2O layer. The band gap estimated from $\lambda \approx 620$ nm band gap = 2.2 ev can be seen. CAC was collected by optical charge carriers which help enhance of absorbency level of n-Cu_2O film at the solid state.

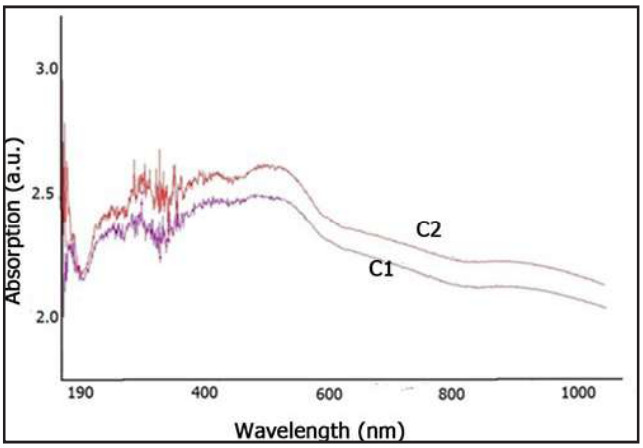

Fig. 4: Diffuse Reflectance Spectra Cu/n-Cu_2O (C1) Fabricated with BPAC 2 mg cm^{-2} (C2) Fabricated with CAC 1 mg cm^{-2}

D. The Time Development of the Photocurrent

Fig. 5 shows the time development of the photocurrent for Cu/n-Cu_2O/CAC solid state cell for different CAC concentration Stable photocurrent were observed for each cell at various CAC concentration The greatest concentration of CAC was found at 1 mg cm^{-2} for the solid state device. When the CAC concentration increases father the steady state photocurrent reductions gradually may be due to the incident light cut off for n-Cu_2O.

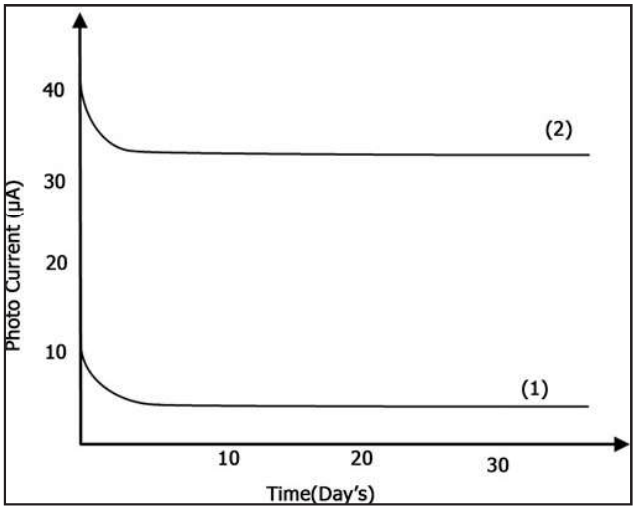

Fig. 5: Photocurrent Development with the Curve of Cu/n-Cu_2O/CAC/ITO for 30 Days (1) Fabricated with CAC of 1 mg cm^{-2} (2) Fabricated with CAC of 2 mg cm^{-2}

The photocurrent generation at Cu/n-Cu_2O/CAC/ITO can describe as follows. Solid state photovoltaic device Cu/n-Cu_2O/ITO prepared in without CAC, any photocurrent observed due to light adsorption. Still only after sandwiching CAC to form Cu/n-Cu_2O/CAC junction device, photocurrent was observation can be explained as following mechanism. Activated Carbon pore structure helps to move the excited electrons from CAC to n-Cu_2O layer to separate photo-generated after absorbing the solar energy. So that the recombination of photo-generated charge carries is suppressed. Activated Carbon particles vastly entered in the n-Cu_2O layer can act as collection centres to transfer the photo-generated carries into the circuit to flow the photo current. This proves that the CAC were serving as an upper electrode for this exacting photovoltaic cells. It should be mention that maximum Power conversion efficiency is nearly 1 % for CAC concentration of 1 mg cm^{-2} Cu/n-Cu_2O/CAC/ITO junction photo electrode and minimum Power conversion efficiency reach is closely 0.8 % for CAC concentration of 2 mg cm^{-2} Cu/n-Cu_2O/ITO junction photo electrode.

IV. Conclusion

A solid state thin film photovoltaic cell produced with Chemically Activated Coconut shell (CAC) and Cu/n-Cu_2O for the first time. The photocurrent development was observed in Cu/n-Cu_2O/CAC/ITO compared with Cu/n-Cu_2O/ITO photo electrodes. The photocurrent growths. When the contact between Cu/n-Cu_2O and ITO was increased and it serves as upper electrode. Significant stability was seen in Cu/n-Cu_2O/CAC solid state photovoltaic cell.

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