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INVESTIGATION OF p-CuI SENSITIZED QUANTUM DOT SOLAR CELLS

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ABSTRACT

A low cost and simple solution for solar cells is obtained with immersing a well cleaned copper plate in a solution with KI and I_2 to prepare p-CuI colloidal layer and then boiled in a $CuSO_4$to deposit n-Cu_2O quantum dots on it. UV spectrophotometer and potentiostat were used to investigate the characteristics. Different sizes of quantum dots were tested aiming the best efficiency conversion level to gain most suited solution for a solar cell to enhance the photocurrent. Results showed that maximum photocurrent (0.5 mA) is obtained when Cu/p-CuI cell is boiled for 20 minutes in 0.003M $CuSO_4$.

Keywords: p-CuI, solar cells, n-Cu_2O, quantum dots

1. INTRODUCTION

The need for clean and renewable energy sources has encouraged the fabrication of low-cost materials for solar energy conversion devices[1]. Traditional semiconductors were not cost effective and have band gaps that are hard to be changed and also their emission frequencies are hard to be manipulated. Fabrication of p-n junctions with Quantum Dots (QD) is seen as the solution for these problems to overcome drawbacks in traditional semiconductors and probably would play an important role in future solar energy conversion devices.

A quantum dot is a portion of matter whose excitons are confined in all three spatial dimensions. Consequently, such materials have electronic properties intermediate between those of bulk semiconductors and those of discrete molecules. It was recently established that QDs generate multiple electron–hole pairs per photon, improving device efficiency[2].

Currently the QD is a field which has gained more attention and more studies are focused in use of solar cells.

In this study preparation of p-CuI sensitized QD photovoltaic cells using an easy fabrication method was discussed. Photoelectrochemical characteristics were presented from V-I characteristics in presence of (10^{-4}M) Fe^{2+}/Fe^{3+}(10^{-2}M) redox couple and absorption characteristics by diffuse reflectance spectra.

2. EXPERIMENTAL

2.1 Preparation of Cu_2O QD sensitized Cu/p-CuI photo electrode

A commercially available 4cm x 8cm Copper plate was smoothed with sand papers till mirror like surface was obtained. That Cu plate was cleaned using a detergent and distilled water to obtain a well cleaned Cu plate. A solution of 75ml was prepared using 402mg of KI, an Iodine crystal, 6ml of Ethanol and distilled water. Cu plate was immersed in the prepared solution for 10 minutes to make CuI colloidal layer on top of Cu plate. Then CuI electrode was immersed in a 0.003M $CuSO_4$ and boiled until a Cu_2O QD sensitized Cu/p-CuI photo electrode was prepared. The sizes of quantum dots were controlled with boiling time.

2.2 Experimental techniques

Absorption properties of the Cu_2O QD sensitized Cu/p-CuI samples were obtained using Shimadzu UV-visible 1800 spectrophotometer. For Photo electrochemical characteristics measurements, HOKUTU DENKO HA-301 potentiostat/galvostat was used with three-electrode configuration while having Pt as counter electrode and AgCl/Ag as the reference electrode. The light source used was a 100W tungsten lamp. All chemicals used for the experiment were analytical grade.

3. RESULTS AND DISCUSSION

3.1 UV-visible absorption analysis

Figure 1 shows the diffuse reflectance spectrums of Cu/p-CuI cell and boiling them in $CuSO_4$ for different times. The peak edges (λ) for Cu_2O were increased from 670 nm to 720 nm when boiling time was increased from 5 minutes to 20 minutes. When boiling time was further increased the peak edges were shifted to 640 nm due to formation of bulk Cu_2O.According to the results p-CuI cell boiled in 0.003M $CuSO_4$ for 20 minutes can be taken as the best result.

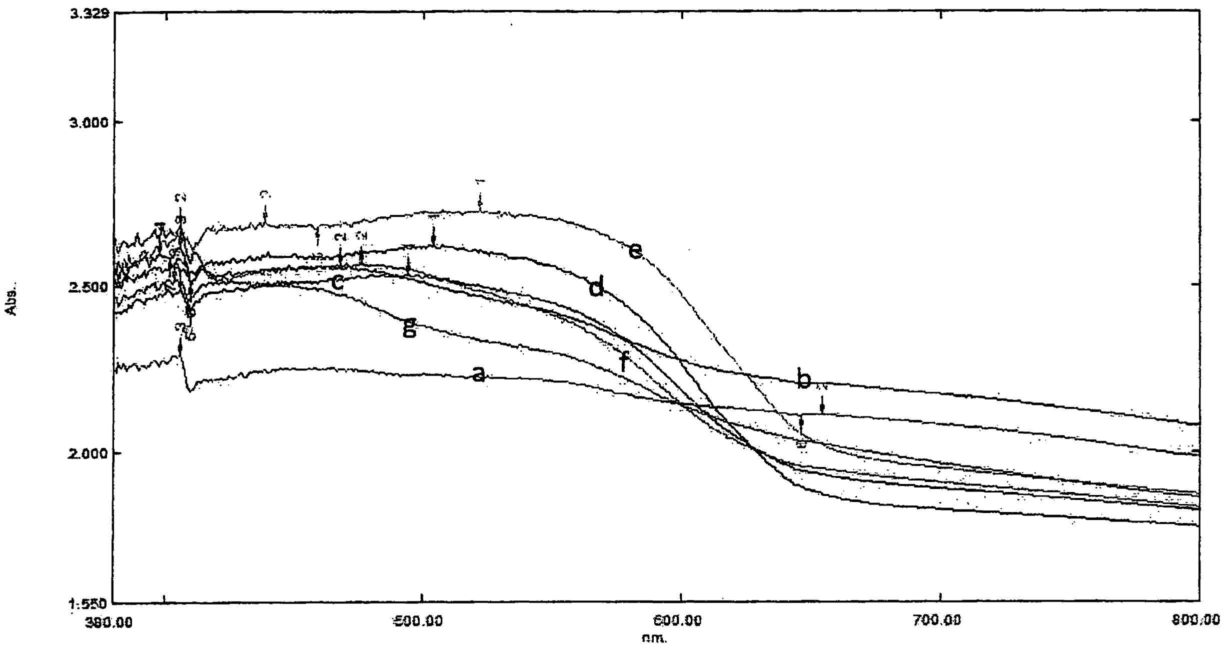


Figure 1: Diffuse reflectance spectra of Cu/p-CuI/n-Cu_2O cells for various boiling time in $CuSO_4$ solution for make various n-Cu_2O layers. (a)CuI (b)5 min (c)10 min (d)15 min (e)20 min (f)30 min (g)40 min

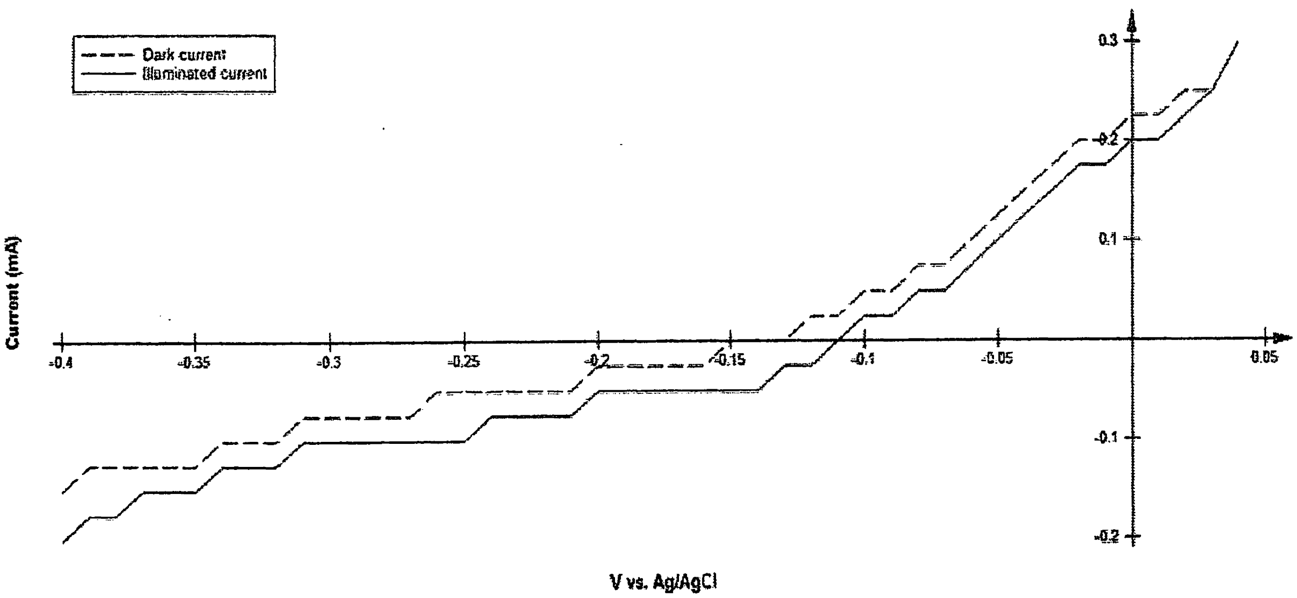
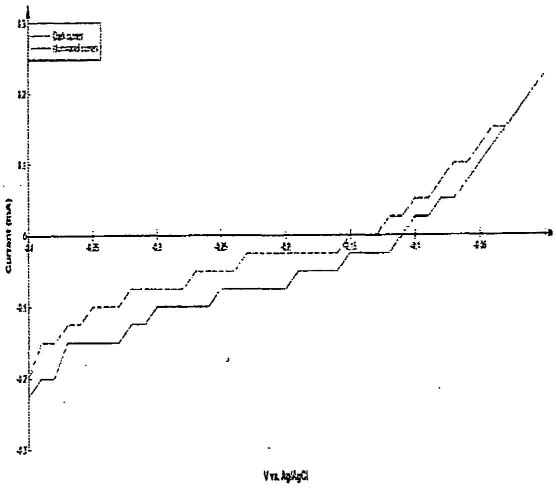
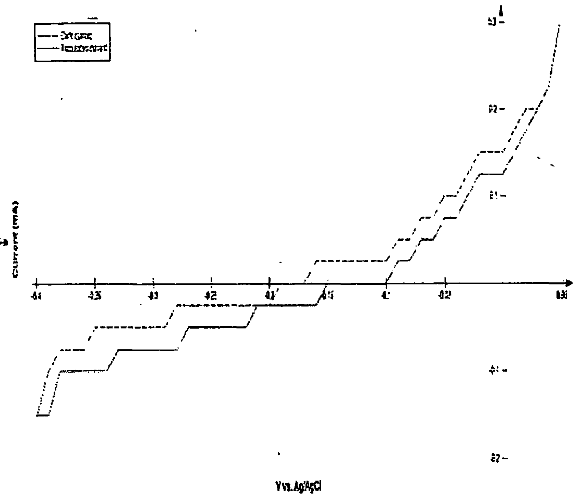


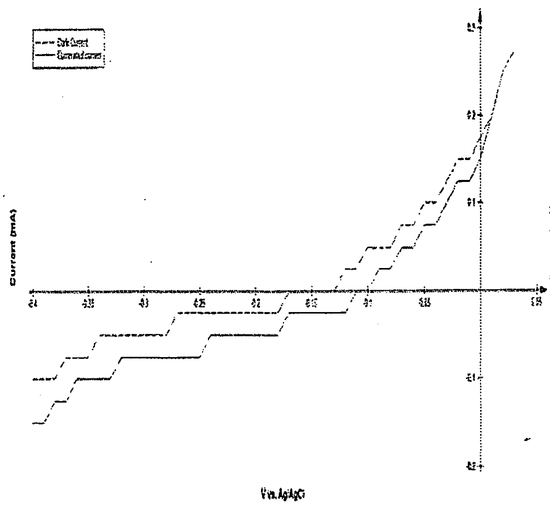
Figure 2: V-I characteristics of Cu/p-CuI cell in the presence of Fe^{2+}/Fe^{3+} redox couple.



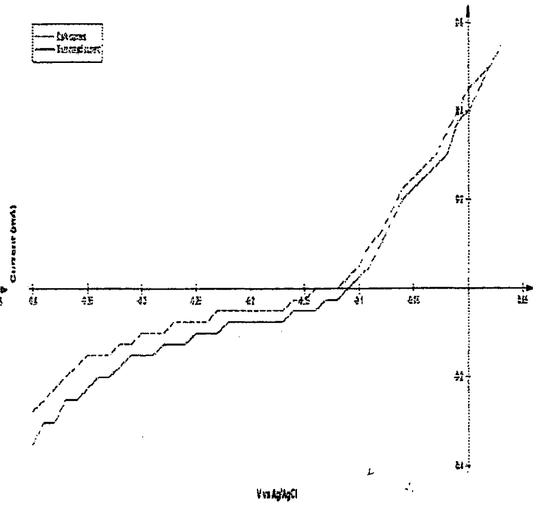
(a) 5 min



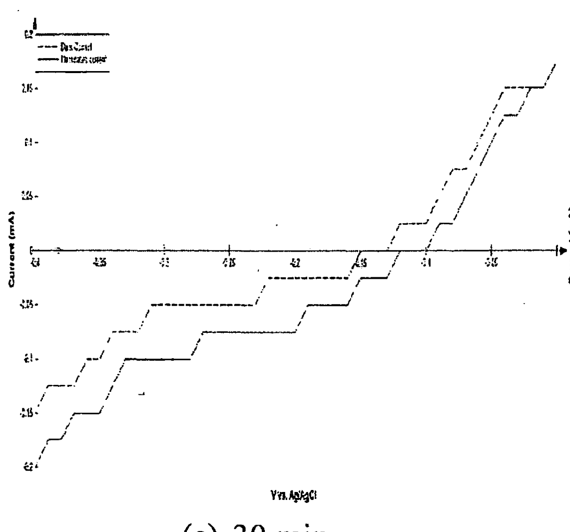
(b) 10 min



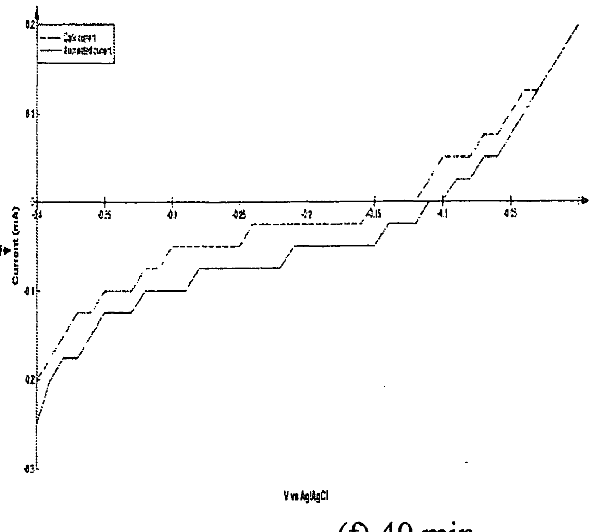
(c) 15 min



(d) 20 min



(e) 30 min



(f) 40 min

Figure 3: V-I characteristics of Cu_2O QD sensitized Cu/p-CuI/n-Cu_2O cells for various boiling time with $CuSO_4$ solution.

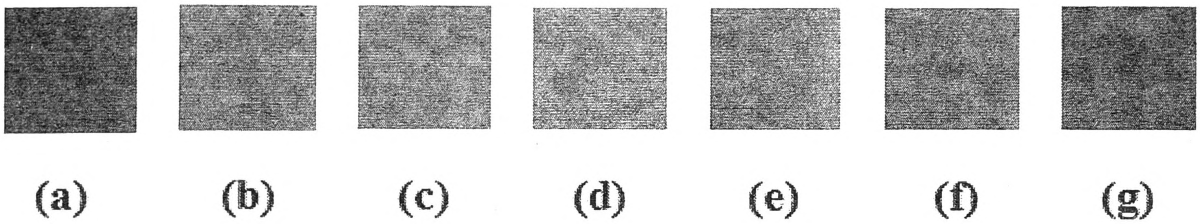


Figure 4: Color variation with boiling time in CuSO4 solution for make various n-Cu2O layers. (a)p-CuI (b)5 min (c)10 min (d)15 min (e)20 min (f)30 min (g)40 min

Table 1: On-set potentials and currents for different boiling times

Boiling time in $CuSO_4$	On-set potential (v)	On-set current (mA)
5	-0.01	0.15
10	0.02	0.75
15	0.02	0.2
20	0.01	0.5
30	-0.02	0.2
40	-0.03	0.175

3.2 V-I characteristics

According to Figure 2 V-I characteristics under 0.005M Fe^{2+}/Fe^{3+} electrolyte the on-set potential was observed at +0.03V (vs. Ag/AgCl) for Cu/p-CuI cell which is the flat band potential. Figure 3 shows the V-I characteristics for cells after sensitization of Cu_2O QD at different boiling times in $CuSO_4$. Onset potential didn't change considerably for boiling times up to 20 minutes. But for both 30 minutes and 40 minutes boiling times there observed a shift in onset potential from positive side to negative side as shown in Table 1. And the onset current was increased up to 0.5mA and then reduced due to formation of bulk Cu_2O.

3.3 Schematic Structure of photo electrodes

After immersing the Cu plate in $KI/I_2$the Cu plates turned ash in color. Then when it is boiled in $CuSO_4$ the ash color becomes yellowish ash. With the increase of boiling time in $CuSO_4$ the Cu/p-CuI cell is gradually turned from yellowish ash to red color as shown in Figure

4.This is due to the formation of Cu_2O quantum_dots and the diameter of those QDs increases with time and ultimately turn into bulk size Cu_2O.

4. CONCLUSION

The application of QD for photovoltaic devices is vital due to their unique optoelectronic properties which are defined by sizes of QDs. The size of a QD easily controllable in preparing cells, thus eliminates the drawbacks in traditional semiconductors. One of the essentials in fabricating photovoltaic cells is high stability, which was observed during this study.

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