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Photochemical cell Yellow 5GN Conversion and Storage of Solar Cell

ABSTRACT

The photovolatges and photocurrent in photogalvanic cell were studies for conversion and storage of solar energy by using yellow 5 GN as a photo sensitizer and EDTA as a reductant. The observed cell performance in terms of photopotential, photocurrent, conversion efficiency, fill factor and storage capacity in terms of half change time are 905.0mV, 450.0uA, 1.26%, 0.216 and 170.0 minutes on irradiation for 140.0 minutes respectively. The effect of different parameters on electrical output of cell was observed. A mechanism has also been proposed for generation of the photophotential and photocurrent in photo galvanic cell.

Keywords: Yellow 5 GN, EDTA, photopotenial, photocurrent & fill factor

INTRODUCTION

Energy is necessary for the survival and substance of life. The solar cells convert sunlight directly in to electricity with acceptable conversion efficiency. The photo galvanic cells are based on some chemical reaction, which rise to high energy products on excitation by photons. This cell works on photogalvanic effect. The photo effects in electrochemical systems were first reported by Becquerel [1]. It has been reported that only negative photo potential should be obtained with carbonyl compounds. The photo galvanic effect was first observed by Rideal and Williams [2], but it was systematically investigated by Rabinowitch[3-4] and later on Suda et al.[5]. K.Jana reported enhancement in the power output of a solar cell consisting of mixed dye [6]. Ameta et al.[7] reported use of toluidine blue nitroloacetic acid (TB-NTA) system in photo galvanic cell for solar energy conversion. They also reported the use of micelles in photo galvanic cell for solar energy conversion and storage in Azur A Glucose system, Bromophenol-EDTA system and Fluoroscein-EDTA system [8]. Gangotri et al studied the photo galvanic effect in mixed reductants system for solar energy conversion and storage.[9]-[11]. Photo galvanic cells containing reductants, surfactants and photosensitizes were reported by

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Meena et al. [12] [19].]Present work is the effort to observe the photochemical study of photo galvanic cell containing Orange-G- EDTA system for solar energy conversion and storage.

EXPERIMENTAL & MATERAILS

The system contains Yellow 5GN, EDTA, NaOH and water, used in the reported system is distilled twice in the laboratory only. The stock solutions of chemicals were prepared in doubly distilled water and were kept away from the sun or in amber colored bottles. The system was systematically set for photo galvanic studies, which consists of electrochemically treated platinum as electrode and saturated calomel electrodes as a reference electrode. The distance between the illuminated and dark electrode is 45 mm. The photosensitive solutions i.e. mixture of solution dye, reductant and sodium hydroxide is filled into the consisting of an H- shaped glass tube. The cell is either painted black or in covered with a black glaze paper leaving a window in one arm. A Pt electrode of (1.0 * 1.0 cm^2) is dipped into one arm and in another arm saturated calomel electrode (SCE) was placed. Terminal of the electrode are connected to a dital pH meter (systronics) to measure the photopotenial and the current is measured by the micrometer (OSAW INDIA). The system is then exposed to source of light (tungsten lamp 200W). A water filter is used to avoid thermal effect of light.

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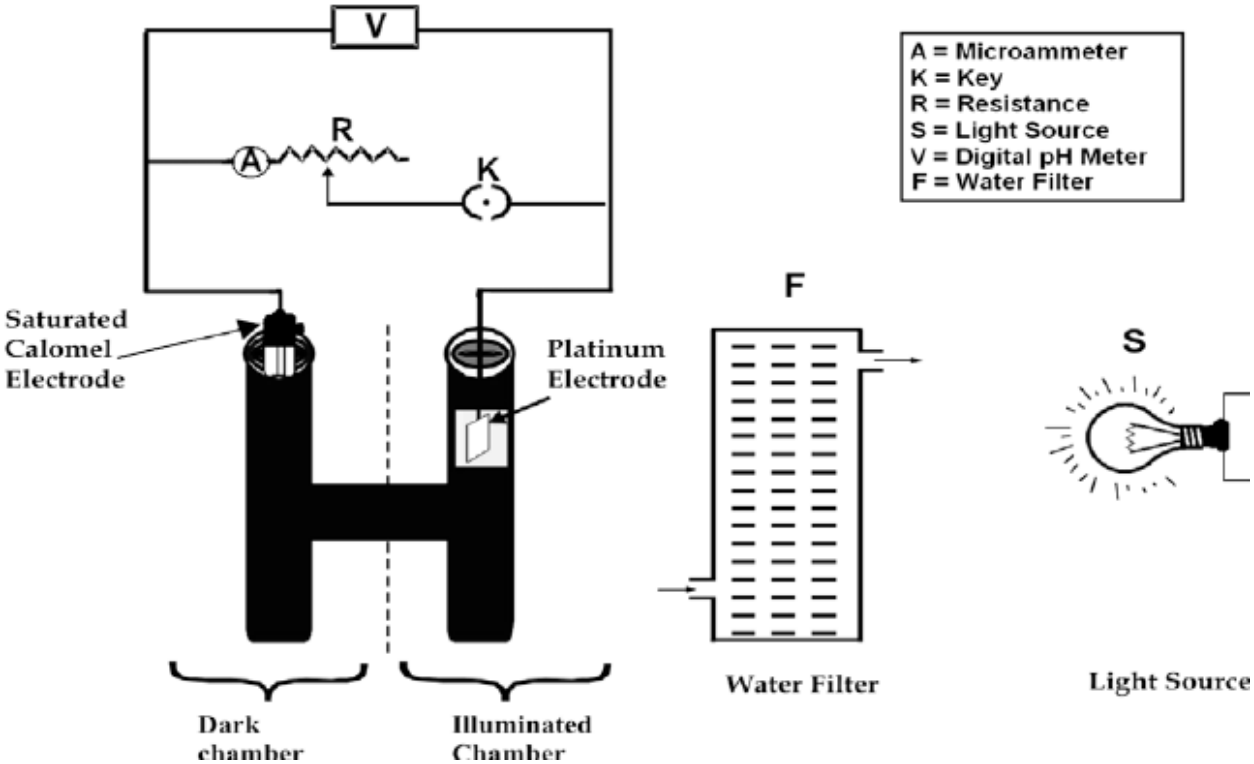
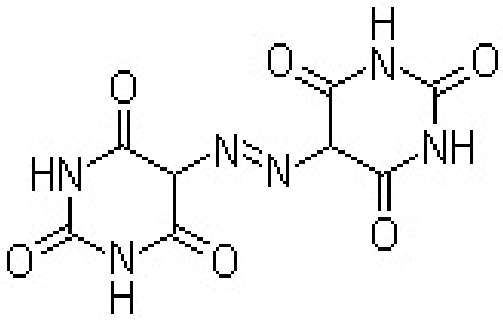
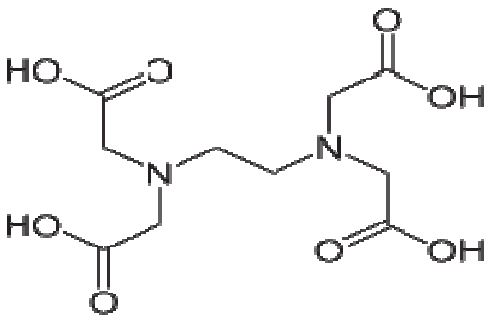


Experimental Set up



Yellow 5GN



EDTA

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RESULT & DISCUSSION

STUDY OF VARIATION IN YELLOW 5 GN DYE

Study of variation dye concentration is founded that the photopotential and photocurrent were increase with the increase in concentration of the dye (Yellow 5GN). A maximum was obtained for a particular value of yellow 5 GN concentrations, above which decrease in the electrical output of the cell was obtained.

Effect of variation in concentration of photo sensitizer

pH=12. Light intensity=10.4mW cm^{-2} Temp.=303K

Concentration(M)	$1.2*10^{-5}$	$1.6*10^{-5}$	$2.4*10^{-5}$	$2.8*10^{-5}$	$3.2*10^{-5}$
Photopotential(mV)	842	909	941	901	843
Photocurrent (uA)	228	250	275	248	213
Power	191.9	227.2	258.7	223.4	179.4

STUDY OF VARIATION IN (EDTA) REDUCTANT

On increasing the concentration of reductant (EDTA), keeping constant the concentration of photosensitizer the cell output was found to increase and reached to a maximum value and then decreased on further increased the concentration. The fall in electrical output at lower concentration of reductant is due to less no. Of molecules available for electron donation and the higher concentration may hinder the movement of dye molecules towards electrode in a desired time limit.

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Effect of variation in concentration of reductant

PH=12. Light intensity=10.4mW cm^{-2} Temp.=303K

EDTA ($2.80*10^{-5}$)	2.22	2.54	2.82	3.12	3.42
Photopotential(mV)	834	889	941	901	827
Photocurrent(uA)	219	244	274	247	217
Power	182.6	216.9	557.8	222.5	179.4

STUDY OF VARIATION IN PH

Study of variation in pH on photoelectric parameters of cell is observed that the cell containing Yellow 5GN to be quite sensitive to the pH of the solution. It was observed that the system works effectively in strong alkaline range. The working range was (pH 10.0 – 12.0). Photopotential of the system was found to increase as the pH increased, and after reaching the maximum pH value, it decreases on further increasing the pH.

Effect of variation in pH

PH	11.6	12.0	12.4	12.8	13.2
Photopotential(mV)	824	905	941	898	836
Photocurrent(uA)	217	251	274	259	222
Power	178.8	227.1	257.8	232.5	185.5

Study of variation in Diffusion length

The maximum photocurrent (i_{max}) and rate of generation of photocurrent decreased with an increase in diffusion length. The value of equilibrium photocurrent (i_{eq}) was also observed to be independent with respect to change in diffusion length (rather it slightly decreases). If the oxidized form of reluctant is formed only in illuminated chamber and it is considered to be the

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electroactive species in dark from the electrode. Therefore it may be conclude that the main electroactive species are the leucos or semi dyes (Photosensitizer) and the dye in the illuminated and dark chamber respectively.

Effect of diffusion length

Variation in diffusion length (mm)	Maximum photocurrent (i_{max}) uA	Equilibrium photocurrent (i_{eq}) uA	Rate of generation of current uA (min^{-1})
35.0	90.0	106.0	38.02
40.0	100.0	105.0	40.05
45.0	110.0	105.0	42.25
50.0	115.0	105.0	45.36
55.0	118.0	104.0	48.75

STUDY OF VARIATION IN TEMPERATURE

It was observed that the photocurrent of the photo galvanic cell is found to be increased with the temperature whereas the photo potential decreased. This is because the internal resistance of the cell decreases at higher temperature, which results in rise in photocurrent, and also there will be a fall in photo potential.

Effect of temperature

Temperature	Photopotential	Photocurrent
293	922	75
298	800	92
303	840	110
308	895	118
313	750	126

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PERFORMANCE OF THE CELL:

Performance of the cell was determined at its power point. It was determined from the rate of fall in power of the cell after the illumination is stopped. An external load was applied to have current and potential values equivalent to the value at power point. Then the time taken to reach the half of the value at power point was noted down. This is termed as $T_{1/2}$ and is actually the measure of the performance of the cell in dark (the storage capacity of the cell).

Fill factor of the cell was determined by using the following formulae –

$$Fill \quad Factor(\eta) = \frac{i_{pp} \times V_{pp}}{V_{oc} \times i_{sc}}$$

Where i_{pp} and V_{pp}, are the photo current and photo potential at power point. V_{oc} and i_{sc} are the Photopotential of open circuit and photocurrent at short circuit.

8. CONVERSION EFFICIENCY OF THE CELL:

Conversion efficiency of the cell was calculated with the help of current and potential values at the power point and the intensity of light. It is defined as the efficiency of the cell to convert light energy in to electrical energy.

The following formula was used.

$$\text{Conversion Efficiency} = \frac{V_{pp} \times i_{pp}}{10.4 \text{ Mw/Cm}^2} \times 100\%$$

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Observation table of Yellow 5GN

Observations	Values
Dark potential	322 mV
Open circuit voltage (VOC)	1422 mV
Photopotential (V)	1100 mV
Equilibrium Photocurrent(i_{eq})	270 mA
Maximum photocurrent (i_{max})	300 mA
Intial generation of photocurrent	25.45 min
Time of illumination	210 min
Storage capacity	80 min
% Stoarge Capacity (t1/2)	57.14 %
Conversion efficiency	1.4488 %
Fill factor	0.50

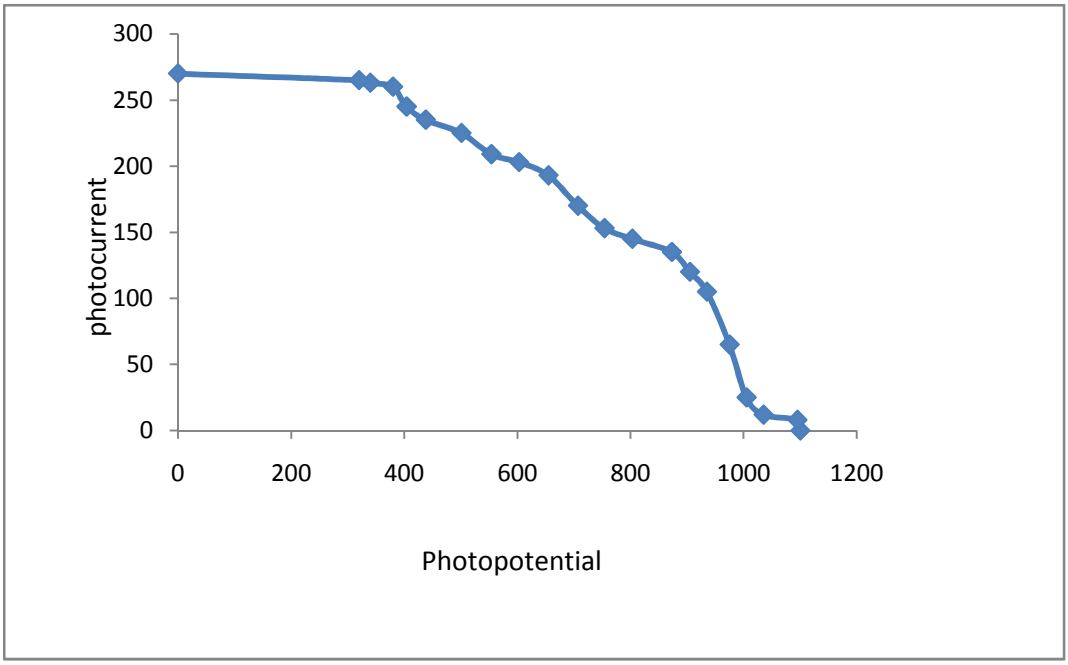

Figure 1; - Current – Voltage (i-V) characteristics of the photogalvanic cell

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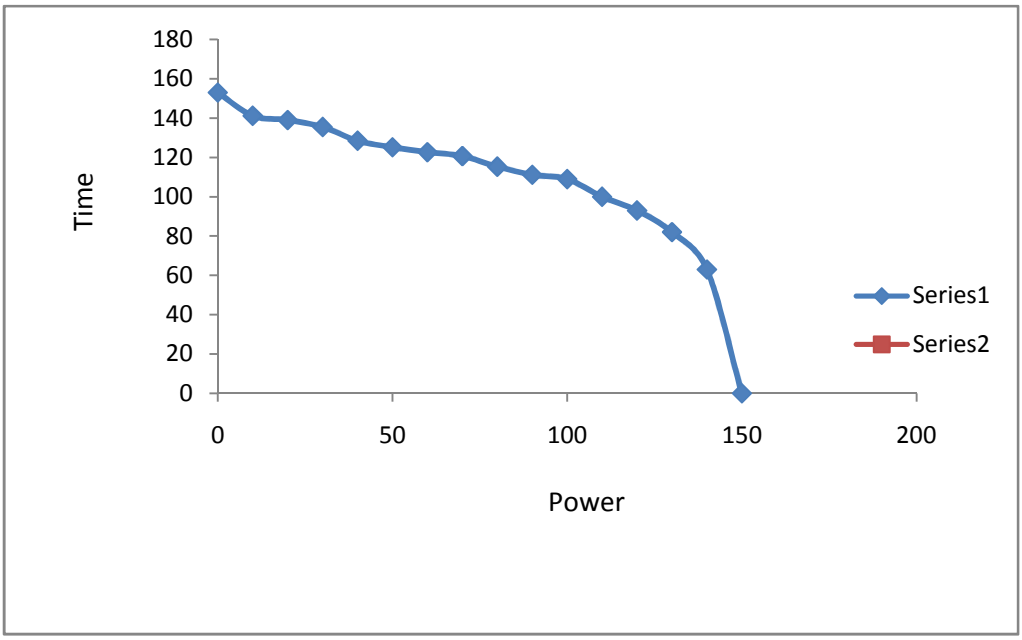

Figure 2 ; - The performance of photo galvanic cell

MECHANISM

On the basis of these observations the suggested mechanism for generation of photocurrent in photogalvanic cells is:-

Dye → Dye*

Dye* + R → dye^- (semi or leuco) + R*

At Pt electrode

$Dye^- \rightarrow Dye + e^-$

Dark chamber

$Dye + e^- \rightarrow Dye^-$ (semi or leuco)

Dye + R → Dye + R

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Where Dye, Dye*,dye^-,R and R^+ are the dye, excited form of dye, semi or leuco dye, reductant and oxidized form of the reductant respectively.

CONCLUSION

On the basis of the results, it is concluded that Yellow 5GN and EDTA can be used successfully in a photogalvanic cell. The conversion efficiency and storage capacity of the cell is 1.4488 % and 150 minutes respectively, on irradiation for 210 minutes developed photogalvanic cell. It has been observed that the reductant has not only enhanced the electrical parameters (i.e. photopotential, photocurrent and power) but also enhanced the conversion efficiency and storage capacity of photogalvanic cell. The efforts are also successful because of the photogalvanic cells showed good prospects of becoming commercially viable.

NOMENCLATURE

ieq = photocurrent at equilibrium

imax = maximum photocurrent

ipp = photocurrent at power point

isc = short circuit current

mv = millivalt

m = molarity

pp = power point

t1\2 = storage capacity of cell

Dv = observed photopotential

VoC = open circuit voltage

Vpp = photo potential at the power point

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n = fill factor

mA = microampere

mW = microwatt

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