Research Paper | E-ISSN NO : 2455-295X | VOLUME : 9 | ISSUE : 3 | SPECIAL ISSUE MARCH-2023

STUDY OF PHOTOGALVANIC CELL USING BIODEGRADABLE SURFACTANT IN TARTRAZINE - FRUCTOSE SYSTEM FOR POWER GENERATION AND STORAGE

ARYA RAKESH KUMAR	PHOTOCHEMICAL LABORATORY, DEPARTMENT OF CHEMISTRY, JAI NARAYAN VYAS UNIVERSITY, FACULTY OF SCIENCE, JODHPUR (RAJASTHAN) 342001, INDIA.
JAYSHREE RATHORE	PHOTOCHEMICAL LABORATORY, DEPARTMENT OF CHEMISTRY, JAI NARAYAN VYAS UNIVERSITY, FACULTY OF SCIENCE, JODHPUR (RAJASTHAN) 342001, INDIA.
LAL MOHAN	PHOTOCHEMICAL LABORATORY, DEPARTMENT OF CHEMISTRY, JAI NARAYAN VYAS UNIVERSITY, FACULTY OF SCIENCE, JODHPUR (RAJASTHAN) 342001, INDIA.

ABSTRACT:

The non–renewable sources of energy have their own limitations along with hazardous processes involved and pollution creating. The scientific community is compelled so is search out the renewable source of energy to feed the whole world with non- polluting nature and commercially viability. It was necessary and proposed to carry out experimental work under the solar parameters. A detailed reaction mechanism for the proposed solar cell for generating of photocurrent and photocurrent has been studied. Photogalvanic Cells were studied using different parameters via photocurrent, photopotential, power conversion efficiency, fill factor and cell performance. The consumption of fossil fuels like wood, coal, kerosene etc. is so rapid is reaching towards their complete depletion. Thus, the solar energy is the best option to fulfil the energy demand. The above values are as following 939.0 A, 712.00 mV, 668.56 W, 6.4278%, 0.4806 and 185.0 minutes. Photogalvanic Cells were studied for solar energy transformation system.

KEYWORDS:

RENEWABLE ENERGY, PHOTOCURRENT, PHOTOPOTENTIAL, FILL FACTOR, CONVERSION EFFICIENCY.

INTRODUCTION

Actual plan of research work was proposed for systematic investigating in the field of photogalvanic cell for solar energy transformation. At earlier stage Rideal and Williams [1] studied about solar radiation, later on Rabinowitch [2] studied about iron iodide process about action sunlight. The PG Cells are used for energy exchange i.e., chemical into light energy. Rabinowitch[3] studied on the photogalvanic properties of the thionine-iron system, and Potter A.C. and Thaller L.H., [4] studied on Efficiency of some iron thionine photogalvanic cell. Peter D., David R., Hobart N., Litchin N., Dale E., Hall A., John and Eckert, [5] studied on Sensitization of an iron-thazinaphotogalvanic cell to the blue. Hall D.E., Wildes P.D. and Lichtin N.N6., studied on Electrodic phenomena at the anode of the totally illuminated, Shigehara K., Nishimura M. and Tsuchida E[7].,Photogalvanic effect of thin layer photo cell composed of thionine/Fe (II) systems. thin layer iron–thionine photogalvanic cell. Nasielski J., A. Kirsch-De Mesmaeker and Leempoel P.,[8] observed the photoelectrochmistry of the RhodamineBhydroquinone system at optically transparent bubbling gas electrodes. Ameta S.C., Khamesra S., Chittora A.K. and Gangotri K.M., [9] Studied on used of sodium Lauryl sulphate in a photogalvanic cell for solar energy conversion and storage: methylene blue –EDTA system. Dube S., Lodha A., Sharma S.L. and Ameta S.C.[10] Studied on use of an Azur-A-NTA system in a photogalvanic cell for solar energy conversion. Gangotri K.M., Meena R.C. and Meena R.[11] Studied on use of miscelles in photogalvanic cells for solar energy conversion and storage: cetyl trimethyl ammonium bromide-glucose-toluidine blue system. Gangotri K.M. and Meena R.C.[12] Studied on use of reductant and photosensitizer in photogalvanic cell for solar energy conversion and storage: oxalic acid - methyline blue system. Genwa K.R. and Gangotri K.M.[13] Studied on Comparative studies in anionic cationic and non-ionic surfactant in photogalvanic cells for solar energy conversion and storage. Point of view: Nitrilotriacidic–Azur B system. Meena R.C., Singh G., Tyagi N. and Kumari M.,[14] Studies of surfactants in photogalvanic cells-NaLS –EDTA and Azur- B. Gangotri P. and Gangotri K.M.,[15] Studies of the Micellar Effect on Photogalvanics: Solar Energy Conversion and Storage–EDTA-Safranine O-TWEEN-80 System. Bhimwal M.K. and Gangotri K.M.,[16] mention the comparative Study on the performance of photogalvanic cell with different photosensitizers for solar energy conversion and storage: D-Xylose-NaLS systems. Genwa K.R. and sagar C.P.,[17] Studied on role of Carmine in Tween 60 – Ascorbic Acid System for Energy Conversion. Genwa K.R. and Chouhan Anju,[18]Studied on optimum efficiency of photogalvanic cell for solar energy conversion and storage containing Brilliant Black PN-Ammonium lauryl Sulphate-EDTA system. Chandra Mahesh and Meena R.C.,[19] Studied on role of Photo Sensitizer-Reductant for Generation of Electrical Energy in Photo galvanic Cell. Saxena Manmeeta, Sharma G.D. Dhiraj, and Roy M.S.,[20] Studied on improved performance of oxidized Alizarin based Quasi solid-state Dye Sensitized solar cell by surface Treatment. Ozuomba J.O., Edebeatu C.C., Opara M.F., Udoye M.C. and Okonkwo N.A.,[21] Studied on performance of a Solar Water Distillation Kit fabricated from Local materials. Deshannavar U.B. Murgod A.A., Golangade M.S., Koli P.B., Banerjee Samyak and Naik N.M.,[22] Studied on photo-Oxidation Process Application for Removal of colour from Textile Industry Effluent. Genwa K.R. and Sagar C.P.,[23] Studied on photoelectrochemical Conversion of Solar Energy Tween 60- Bromocresol Purple. Gunsaria R.K. and Meena Ram Narayan,[24] Studies of Cationic Micelles on Photogalvanic Cells for Solar Energy Conversion and Storage. Nair Smita,[25] observed the Study of Transition Metal Complex of Diuretic Drug and study of its Phyco-chemical properties as Potential Therapeutic Agent Mohan Lal and Gangotri K.M.[26-28]Studied on comparative study the performance of photogalvanic cells with mixed surfactant for solar energy conversion and storage: D-Xylose Methylene Blue system. Rathore Jayshree and Lal Mohan[29] Studied on Study of photogalvanic effect in photogalvanic cell containing single surfactant as DSS, tartrazine as a photosensitizer and EDTA as reductant for solar energy conversion and storage. A detailed literature survey about different photogalvanic cell[30] has been used in solar transformation for best results.

MATERIAL AND METHODS:

Dye-tartrazine, reductant-D-fructose, Surfactant-lauryl glucoside(carbon pot), NaOH(1N), Double distilled water (DDW), 2-Multi-meter (The first multi-meter is used to measure potential as a substitute for a digital potentiometer another multimetar was used as a substitute for a micrometer to measure current), 250 - k carbon pot (carbon potentiometer), U-shaped glass vessel (beaker), Saturated calomel electrode (S), Platinum electrode (P), Resistance key (K), Digital pH meter and 200 W tungsten bulb. The present research project of PG Cell is studied by U-shaped glass vessel which was fabricated. The total volume of experimental set was 25 ml including solution dye surfactant and reductants. the electrical circuit was completed by using saturated calomel electrode, 250 k roistered(carbon pot), U-shaped glass vessel, platinum electrode,250 - k carbon pot (carbon potentiometer), resistance key, digital multi-meter's, and 200 W tungsten bulb. During experiments, water filter was used for IR light. The **C-Wire** was connected with saturated calomel electrode and another **S-Wire** was connected with platinum foil electrode. The pH of the solution was adjusted and measured by a pH meter. U-shaped glass vessel. Photogalvanic cell was fabricated with different surfactants, dye and reductant solutions were used for investigation.

RESULTS AND DISCUSSION

EFFECT OF VARIATION OF LAURYL GLUCOSIDE CONCENTRATION ON THE PG-CELL:

During experiment stage solar, electric output was increased on increasing the concentration of lauryl glucoside and reached to optimum position (at PH 12.18) and on subsequent decrease on increasing of lauryl glucoside concentration. The observed results are shown in table 3.1

EFFECT OF VARIATION OF TARTRAZINE (DYE) CONCENTRATION ON THE SYSTEM:

During experiment stage, solar electric output was increased on increasing the concentration of tartrazine and reached to optimum position and on subsequent decrease on increasing of tartrazine concentration. The observed results are shown in table 1.1

EFFECT OF VARIATION OF D-FRUCTOSE (REDUCTANT) CONCENTRATION ON THE SYSTEM:

During experiment stage, solar electric output was increased on increasing the concentration of D-fructose and reached to optimum position and on subsequent decrease on increasing of tartrazine concentration. The observed results are shown in table 2.1

EFFECT OF VARIATION OF NAOH (PH) CONCENTRATION ON THE SYSTEM:

During experiment stage, solar electric output was increased on increasing the concentration of ***NaOH*** and reached to optimum position and on subsequent decrease on increasing of ***NaOH*** concentration. The observed results are shown in table 4.1

EFFECT OF VARIATION OF DIFFUSION LENGTH ON THE SYSTEM:

During experiment stage, solar electric output was increased on increasing the ***Diffusion length*** and reached to optimum position. On increasing the value of ***Diffusion length***, the value of i_{max} increased as well as a good balance was observed in the value of i_{eq} and the comparative results of rate of initial generation of current were also obtained. The observed results are shown in table 5.1

EFFECT OF VARIATION OF ELECTRODE AREA ON THE SYSTEM:

During experiment stage, solar electric output was increased on increasing the ***Electrode Area*** and reached to optimum position. On increasing the value of ***Electrode Area***, the value of i_{max} increased as well as a good balance was observed in the value of i_{eq}. The observed results are shown in table 6.1

CURRENT–VOLTAGE (I-V) CHARACTERISTICS OF THE PHOTOGALVANIC CELL:

By using, following formula fill factor of PG-cell was calculated

$$\text{Fill factor}\,(\eta) = \frac{V_{pp} \times i_{pp}}{V_{oc} \times i_{sc}} \quad ......(1)$$

Where:

v_{pp} = Potential at power point=*712 mV*

i_{pp} = Current at power point=*939 μA*

V_{oc} = Potential at open circuit =1130*mV*

i_{sc} = Current at short circuit=*1231 μA*

(□) = Value of fill factor= *0.4806*

Ppp = The power point of cell (pp) *= 668.56μW*

***CELL PERFORMANCE AND CONVERSION EFFICIENCY*:**

By using, following formula fill factor of PG-cell was calculated

$$\text{Conversion efficiency} = \frac{V_{pp} \times i_{pp}}{A\ 10.4 mWcm^{-2}} \times 100\% \quad \text{......(2)}$$

Where:

V_{pp}, = Photopotential at power point,

i_{pp} = Photocurrent at power point,

A = Electrode area for pg cell

***MECHANISM OF PHOTOVOLTAGE AND PHOTOCURRENT GENERATION IN A CELL*:**

ILLUMINATED CHAMBER (AT PLATINUM ELECTRODE):

During experiment, dye molecule gets excited by absorption of sun light and converted in to semi or leuco form. Reductant molecules get in its oxidized form and subsequently semi form of dye molecule loss the electron and retuned into its original state.

CHEMICAL REACTION AT ILLUMINATE CHAMBER

Tartrazine ⟶ *Tartrazine ** -------------- *(i)*

*Tartrazine * + Fructose* ⟶ *Tartrazine⁻ + fructose⁺* ------------- *(ii)*

CHEMICAL REACTION AT PLATINUM ELECTRODE:

Tartrazine⁻ ⟶ *TZ + e⁻* ------------ *(iii)*

DARK CHAMBER:

At counter electrode: Tartrazine molecule accept an electron from electrode and converted into Tartrazine⁻ and at termination stage, Tartrazine⁻ converted into Tartrazine molecule and oxidized form of Fructose combine with Tartrazine molecule to give original dye and reductants molecule and the cycle will go on.

Tartrazine + e⁻ ⟶ *Tartrazine⁻* ------------ *(iv)*

Tartrazine⁻ + Fructose⁺ ⟶ *Tartrazine + Fructose* ------------ *(v)*

Where:

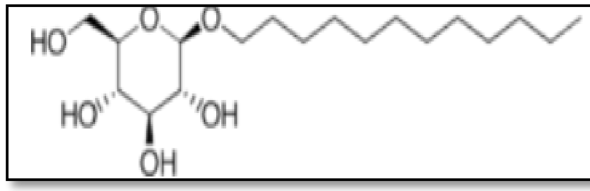
Tartrazine = Dye molecule

Tartrazine * = Excited dye molecule

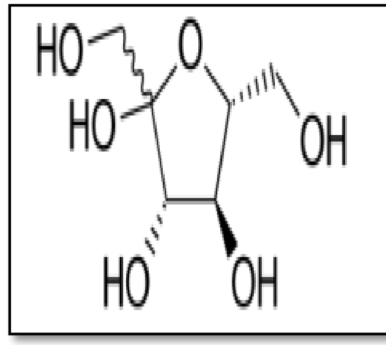
Tartrazine⁻ = Semi for of dye molecule

Fructose = Reductant molecule

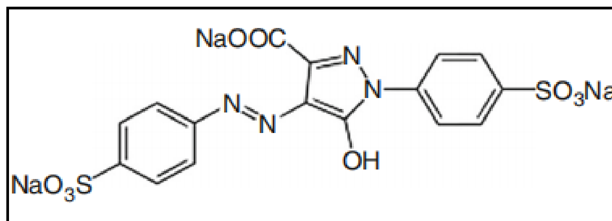
Fructose⁺ = Oxidized form of the reductant,



LAURYL GLUCOSIDE



D-FRUCTOSE



Structural formula of tartrazine

MODIFIED DIAGRAM OF THE PG CELL SETUP USED IN THE PRESENT RESEARCH WORK

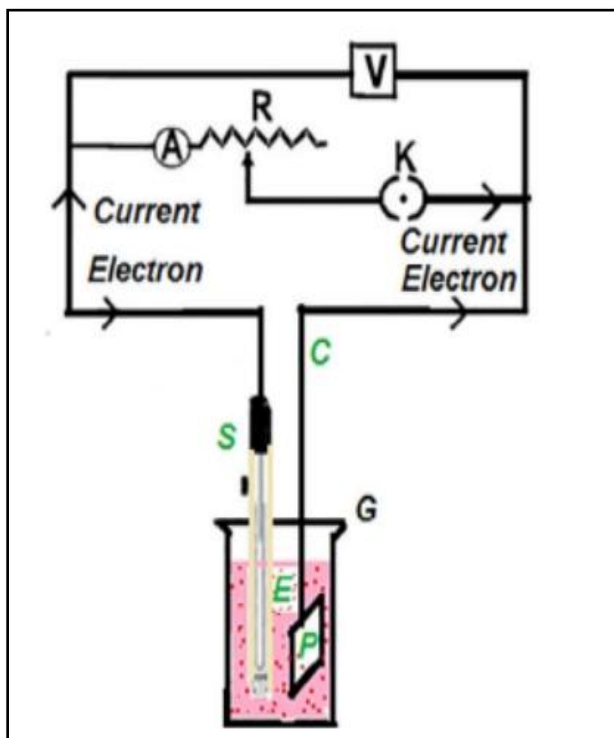


TABLE: 1.1, SHOWING EFFECTS OF VARIATION OF TARTRAZINE (DYE) CONCENTRATION ON ELECTRICAL OUTPUT OF PHOTOGALVANIC CELL.

Concentration	Cell Parameter					
(Tartrazine×10^{-5} M)	Photo potential (mV)	Photocurrent (μA)	Power (μW)	C.E.	F.F(□)	$t_{0.5}$(min)
1.70	930.00	496.00	461.28			
1.84	945.00	418.00	395.10			
1.98	712.00	939.00	**668.56**	6.42	0.48	185.0
2.72	1008.00	440.00	443.52			
2.85	925.00	423.00	391.27			

At D-fructose = 2.22×10^{-3} M, L.G. = 2.30×10^{-3} M, temp.=311.55 K, pt electrode area=1.0×1.0 cm ^{2}, Light intensity =10.4mW cm^{-2}, diffusion length, $D_{L=}$ 4.5 cm, pH=12.18.

TARTRAZINE-D-FRUCTOSE-L.G. SYSTEM

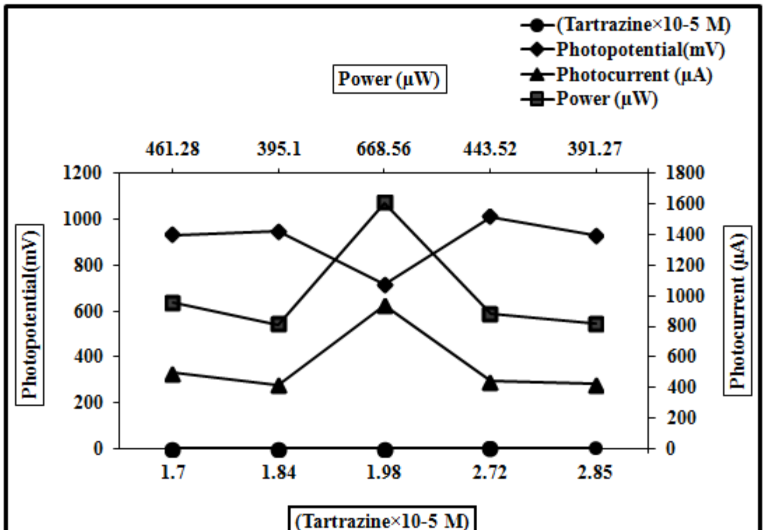


FIG:1.1; CONCENTRATION OF DYE (TARTRAZINE) EFFECT

TABLE: 2.1, SHOWING EFFECTS OF VARIATION OF D-FRUCTOSE CONCENTRATION ON ELECTRICAL OUTPUT OF PHOTOGALVANIC CELL.

Concentration	Cell Parameter					
(D-fructose×10^{-3} M)	Photo potential (mV)	Photocurrent (μA)	Power (μW)	C.E.	F.F.(□)	$t_{0.5}$(min)
1.18	985.00	342.00	336.87			
2.00	947.00	410.00	388.27			
2.22	712.00	939.00	**668.56**	6.42	0.48	185.0
2.24	1096.00	373.00	408.80			
2.26	918.00	380.00	348.84			

At (Dye) Tartrazine×10^{-5}M, L.G.=10^{-3} M, temp.=311.55 K, pH=12.18, Light intensity =10.4mW cm^{-2}, diffusion length, $D_{L=}$ 4.5 cm, Pt electrode area=1.0×1.0 cm ^{2}

TARTRAZINE-D-FRUCTOSE-L.G. SYSTEM

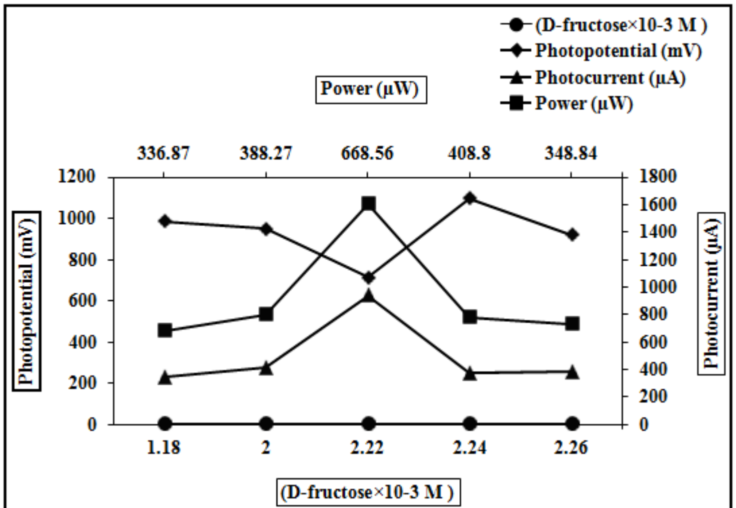


FIG:2.1; CONCENTRATION OF REDUCTANT [D-FRUCTOSE] EFFECT

TABLE: 3.1, SHOWING EFFECTS OF VARIATION OF LAURYL GLUCOSIDE (L.G.) CONCENTRATION ON ELECTRICAL OUTPUT OF PHOTOGALVANIC CELL.

Concentration	Cell Parameter					
(L.G.×10^{-3} M)	Photo potential (mV)	Photocurrent (µA)	Power (µW)	C.E.	F.F. (□)	$t_{0.5}$ (min.)
2.10	698.00	756.00	527.68			
2.20	623.00	843.00	525.18			
2.30	712.00	939.00	**668.56**	6.42	0.48	185.0
2.40	695.76	765.00	531.67			
2.50	736.00	432.00	317.95			

At (Dye) Tartrazine×10^{-5}M, D-fructose = 2.22×10^{-3} M, temp.=311.55 K, pt electrode area=1.0×1.0 cm ^{2}, Light intensity =10.4mW cm^{-2}, diffusion length, $D_{L=}$ 4.5 cm, pH=12.18.

TARTRAZINE-D-FRUCTOSE-L.G.-SYSTEM

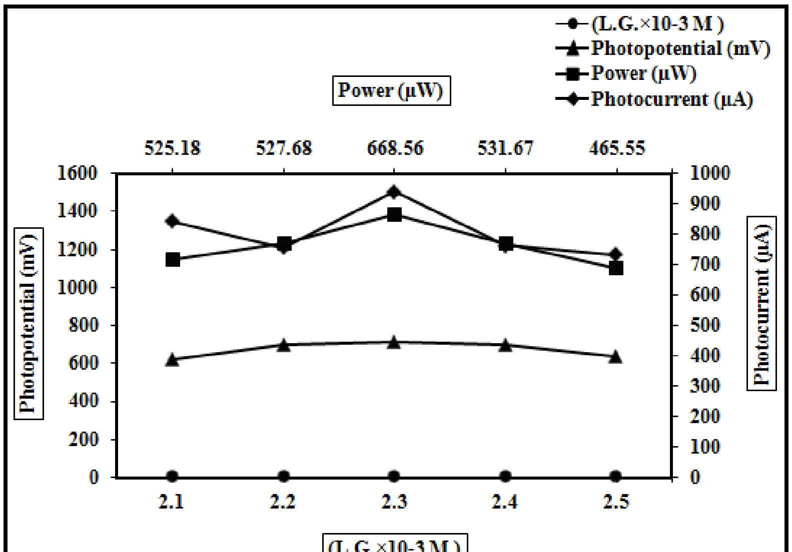


Fig:3.1; CONCENTRATION OF SURFACTANT [L.G.] EFFECT

TABLE: 4.1; SHOWING EFFECTS OF VARIATION OF NAOH (PH) CONCENTRATION ON ELECTRICAL OUTPUT OF PHOTOGALVANIC CELL.

pH	Cell Parameter					
	Photo potential (mV)	Photocurrent (µA)	Power (µW)	C.E.	F.F.(□)	$t_{0.5}$ (min.)
12.11	572.00	768.00	439.29			
12.15	587.00	786.00	461.38			
12.18	712.00	939.00	**668.56**	6.42	0.48	185.0
12.25	697.00	815.00	568.05			
12.32	615.00	663.00	407.75			

At (Dye) Tartrazine×10^{-5}M, D-fructose = 2.22×10^{-3} M, temp.=311.55 K, pt electrode area=1.0×1.0 cm ^{2}, Light intensity =10.4mW cm^{-2} , diffusion length, $D_{L=}$ 4.5 cm, pH=12.18, L.G.= 2.30×10^{-3} M.

TARTRAZINE-D-FRUCTOSE-L.G. SYSTEM

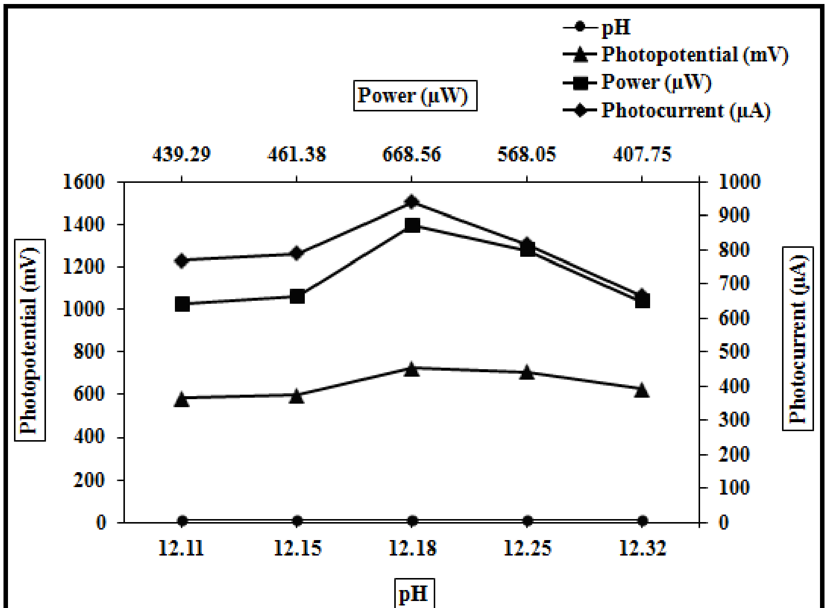


Fig:4.1; IMPACT OF pH VARIATION

TABLE: 5.1, SHOWING EFFECTS OF DIFFUSION LENGTH ON ELECTRICAL OUTPUT OF PHOTOGALVANIC CELL

Diffusion Length (DL)	Maximum Photocurrent i_{max} (µA)	Equilibrium Photocurrent i_{eq} (µA)	Rate of initial Generation of Current (µA min^{-1})
25.0	1300.0	1280.0	44.04
30.0	1313.0	1263.0	44.11
35.0	1325.0	1242.0	45.23
40.0	1328.0	1223.0	45.42
45.0	1334.0	1195.0	45.53

At Dye Tartrazine×10^{-5}M, D-fructose = 2.22×10^{-3} M, temp.=311.55 K, pt electrode area=1.0×1.0 cm ^{2}, Light intensity =10.4mW cm^{-2} , diffusion length, $D_{L=}$ 4.5 cm, pH=12.18, L.G.= 2.30×10^{-3} M.

TARTRAZINE-D-FRUCTOSE-L.G.SYSTEM

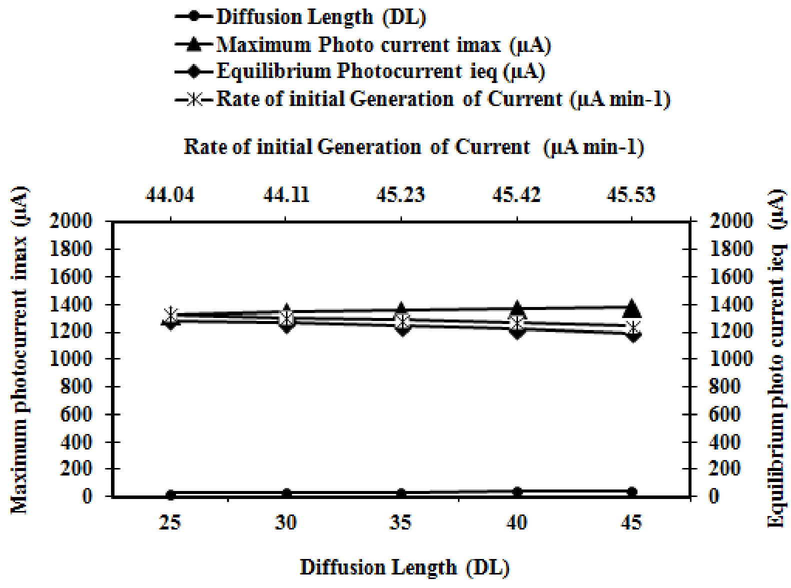


Fig:5.1; Showing variation effects of Diffusion length on electrical output of PG- cell

TABLE: 6.1; SHOWING EFFECTS OF ELECTRODE AREA ON ELECTRICAL OUTPUT OF PHOTOGALVANIC CELL

Electrode Area (cm^2)	Electrode Area (cm^2)	
	Maximum Photocurrent i_{max} (µA)	Equilibrium Photocurrent i_{eq} (µA)
0.3	1327	1230
0.4	1342	1263
0.5	1363	1280
1.0	1380	1305
1.1	1387	1323

At Dye Tartrazine×10^{-5}M, D-fructose = 2.22×10^{-3} M, temp.=311.55 K, Pt electrode area=1.0×1.0.cm^{2}, Light intensity =10.4mW cm^{-2}, Diffusion length, $D_{L=}$ 4.5 cm, pH=12.18, L.G.= 2.30×10^{-3} M

FIG:-6.1; SHOWING VARIATION EFFECT OF ELECTRODE AREA ON CURRENT PARAMETERS OF TARTRAZINE-D-FRUCTOSE -LAURYL GLUCOSIDE PG-CELL SYSTEM.

TARTRAZINE-D-FRUCTOSE-L.G. SYSTEM

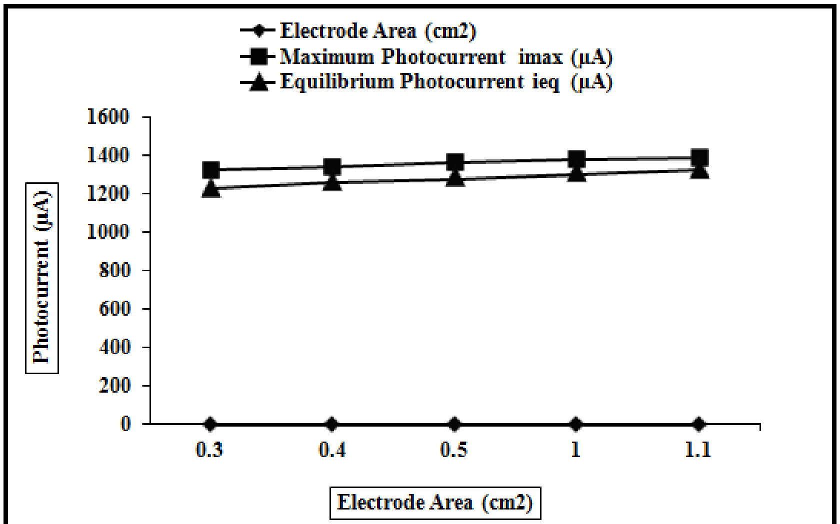


Fig:6.1; IMPACT OF ELECTRODE AREA

TABLE: 7.1; SHOWING CURRENT- VOLTAGE (I-V) CHARACTERISTICS OF THE PHOTOGALVANIC CELL: CHARGING TIME: - 45 MINUTE, BULB ON TIME (I-V) CHARACTERISTICS PROCESS

Potential (mV)	Photocurrent (μA)	Power point (μW)	Fill-factor (η)
1130	0.0	0	
1111	5.0	5.555	
1095	15.0	16.425	
1074	30.0	32.220	
1068	45.0	48.060	
1053	55.0	57.915	
1046	65.0	67.990	
1031	85.0	87.635	
998	95.0	94.810	
972	109.0	105.948	
969	146.0	141.474	
953	184.0	175.352	
934	261.0	243.774	
905	272.0	246.160	
886	342.0	303.012	
862	415.0	357.730	
846	552.0	466.992	
829	672.0	557.088	
801	741.0	593.541	
777	794.0	616.938	
734	823.0	604.082	
712 (Vpp)	**939.0 (ipp)**	**668.568 (Ppp)**	**0.4806**
659	1005.0	662.295	
614	1012.0	621.368	
575	1023.0	588.225	
564	1049.0	591.636	
540	1120.0	604.800	
462	1149.0	530.838	
413	1178.0	486.514	
375	1193.0	447.375	
344	1228.0	422.432	
253	1230.0	309.960	
142	1231.0	174.802	
0.0	1232.0	0.0	

TARTRAZINE-D-FRUCTOSE-L.G.SYSTEM

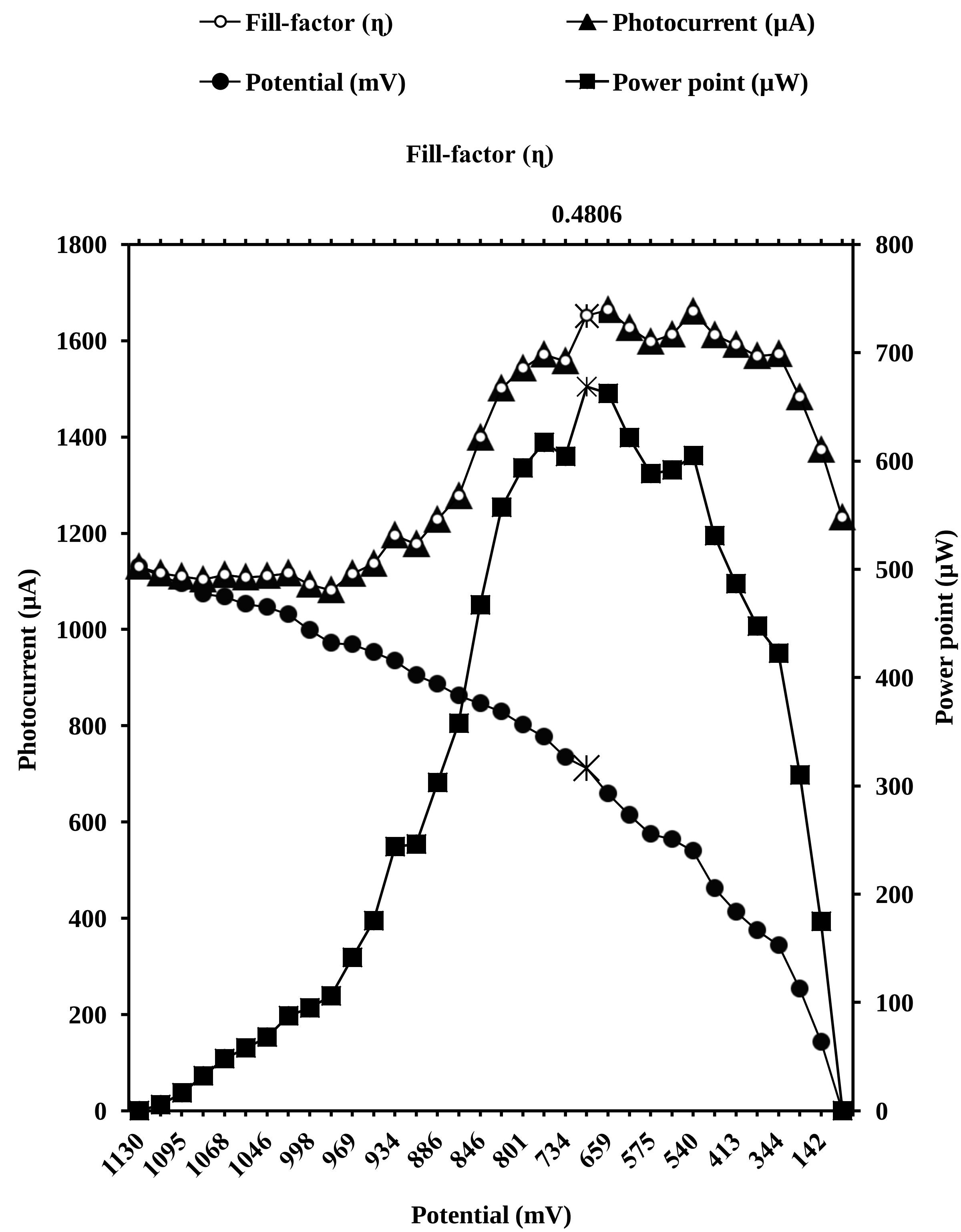


Fig:7.1; CELL CHARACTERISTICS BASED ON CURRENT VOLTAGE (i-V)

TABLE: 8.1, SHOWING TIME- POWER CHARACTERISTICS OF THE PHOTOGALVANIC CELL:

Performance time of the Photo galvanic-cell:-185 Minute, At Bulb off time performance of the Photo galvanic cell characteristics process mention in the table:-

Time(Min.)	Power (µ W)
0.0	668.56
0.5	665.40
10.0	662.13
15.0	659.67
20.0	657.18
25.0	655.65
30.0	653.26
35.0	651.29
40.0	648.90
45.0	646.39
50.0	641.51
55.0	636.62
60.0	633..11
65.0	629.33
70.0	624.47
75.0	619.92
80.0	614.21
85.0	609.83
90.0	604.74
95.0	600.54
100.0	599.13
105.0	595.23
110.0	591.17
115.0	587.12
120.0	583.89
125.0	580.22
130.0	578.82
135.0	561.37
140.0	546.51
145.0	526.22
150.0	502.09
155.0	480.11
160.0	463.68

165.0	440.74
170.0	425.90
175.0	398.65
180.0	359.78
185.0 ($t_{0.5}$)	**334.32 ($P_{0.5}$)**
190.0	324.29
195.0	290.27
200.0	256.62

TARTRAZINE- D-FRUCTOSE - L.G. – SYSTEM

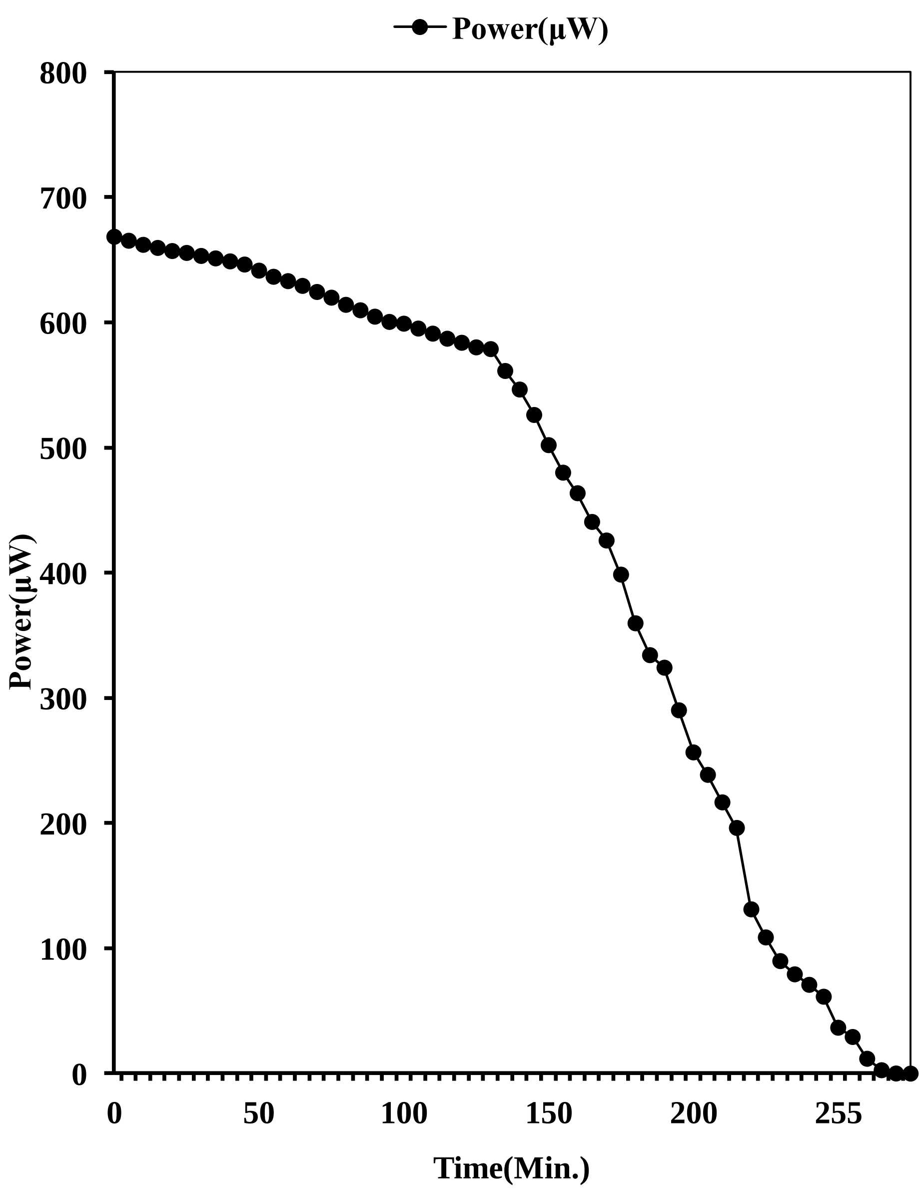


FIG:8.1; SHOWING TIME- POWER CHARACTERISTICS CURVE OF THE PHOTOGALVANIC CELL

CONCLUSION

On the basis of observed results, we are concluded that the single surfactant affected photogalvanic cell more than mixed surfactant. The single surfactant has not only enhanced the conversion efficiency but storage capacity of photo galvanic cells also an exhaustive efforts still have the scope to enhance electrical output as well as storage capacity of photogalvanic cells along with reduction in their cost to get commercial viability. The conversion efficiency, $t_{1/2}$ and fill factor are recorded as 6.42%, 185.0 min. and 0.48 respectively in PG system.

ACKNOWLEDGMENT

Authors are thankful to Head, Department of Chemistry J.N.V. University Jodhpur for providing necessary facilities.

REFERENCES

1. Rideal E.K. and Williams D.C., The action of light on the ferrous iodine iodide equilibrium. *J. Chem. Soc.,***127**, 258 **(1925)**

2. Rabinowitch E., The photogalvanic effect I: The photochemical properties of the thionine-iron system. *J. Chem. Physics.,* **8(7),** 551 **(1940)**

3. Rabinowitch E., The photogalvanic effect II: The photogalvanic properties of the thionine-iron system. *J. Chem. Physics.,* **8(7)**, 560 **(1940)**

4. Potter A.C. and Thaller L.H., Efficiency of some iron thionine photogalvanic cell. *Solar Energy.,* **3 (4)**, 1 **(1959)**

5. Peter D., David R., Hobart N., Litchin N., Dale E., Hall A., John and Eckert, Sensitization of an iron-thazinaphotogalvanic cell to the blue: An improved match to the insolation spectrum. *Solar Energy.,***19(5)**, 567 **(1970)**

6. Hall D.E., Wildes P.D. and Lichtin N.N., Electrodic phenomena at the anode of the totally illuminated, thin layer iron–thionine photogalvanic cell. J. *Electrochem. Soc.* **125(9)**, 1365 **(1978)**

7. Shigehara K., Nishimura M. and Tsuchida E., Photogalvanic effect of thin layer photo cell composed of thionine/Fe (II) systems. *Electrochem Acta.* **23(9)**, 855 **(1978)**

8. Nasielski J., A. Kirsch-De Mesmaeker and Leempoel P., The photoelectrochmistry of the RhodamineBhydroquinone system at optically transparent bubbling gas electrodes. *Electrochim Act,* **23(7)**, 605 **(1978)**

9. Ameta S.C., Khamesra S., Chittora A.K. and Gangotri K.M., Used of sodium Lauryl sulphate in a photogalvanic cell for solar energy conversion and storage: methylene blue –EDTA system. *Int. J. Ene. Res.,* **13(6),** 643**(1989)**

10. Dube S., Lodha A., Sharma S.L. and Ameta S.C., Use of an Azur-A-NTA system in a photogalvanic cell for solar energy conversion. *Int. J. Ene. Res.,***17(5),** 359-**(1978)**

11. Gangotri K.M., Meena R.C. and Meena R., Use of miscelles in photogalvanic cells for solar energy conversion and storage: cetyl trimethyl ammonium bromide-glucose-toluidine blue system. *J. Photochem. Photobio. A: Chemistry,***123(1)**, 93**(1999)**

12. Gangotri K.M. and Meena R.C., Use of reductant and photosensitizer in photogalvanic cell for solar energy conversion and storage: oxalic acid – Methylene blue system, J*ournal of Photochemical and Photobiological A: Chemistry,* ***141(2)***, 175 **(2001)**

13. Genwa K.R. and Gangotri K.M., Comparative studies in anionic cationic and non-ionic surfactant in photogalvanic cells for solar energy conversion and storage. Point of view: Nitrilotriacidic–Azur B system. *J.Indian Chem.Soc.,* **81(7)**, 592 **(2004)**

14. Meena R.C., Singh G., Tyagi N. and Kumari M., Studies of surfactants in photogalvanic cells-NaLS –EDTA and Azur- B. *J.Chem.Soc.,***116(3)**, 179 **(2004)**

15. Gangotri P. and Gangotri K.M., Studies of the Micellar Effect on Photogalvanics: Solar Energy Conversion and Storage–EDTA-Safranine O-TWEEN-80 System. *Ara. J. Sci. Eng.,***35(1A)**, 19 **(2010)**

16. Bhimwal M.K. and Gangotri K.M., A Comparative Study on the performance of photogalvanic cell with different photosensitizers for solar energy conversion and storage: D-Xylose-NaLS systems. *Energy,* **36**, 1324 **(2011)**

17. Genwa K.R. and sagar C.P., Role of Carmine in Tween 60 – Ascorbic Acid System for Energy Conversion. *Re. J.Recent Sci.,***1(ISC–2011),** 62 **(2012)**

18. Genwa K.R. and Chouhan Anju, Optimum efficiency of photogalvanic cell for solar energy conversion and storage containing Brilliant Black PN-Ammonium lauryl Sulphate-EDTA system. *Re. J.Recent Sci.,* **1(ISC-2011),** 117 **(2012)**

19. Chandra Mahesh and Meena R.C., Role of Photo Sensitizer-Reductant for Generation of Electrical Energy in Photo galvanic Cell. *Res. J. Recent Sci.***1(1)**, 63 (**2011)**

20. Saxena Manmeeta, Sharma G.D. Dhiraj, and Roy M.S., Improved performance of oxidized Alizarin based Quasi solid-state Dye Sensitized solar cell by surface Treatment. *Res. J. Recent Sci.***2(2),** 61 **(2012)**

21. Ozuomba J.O., Edebeatu C.C., Opara M.F., Udoye M.C. and Okonkwo N.A., Performance of a Solar Water Distillation Kit fabricated from Local materials. *Res. J. Recent Sci.* **2(3),** 64 **(2012)**

22. Deshannavar U.B. Murgod A.A., Golangade M.S., Koli P.B., Banerjee Samyak and Naik N.M., Photo-Oxidation Process, Application for Removal of color from Textile Industry Effluent. *Res. J. Chem. Sci.,* **2(10),** 75 **(2012)**

23. Genwa K.R. and Sagar C.P., Photoelectrochemical Conversion of Solar Energy Tween 60- Bromocresol Purple. Int. J. Ene. Sci., **1(3)** 169 **(2011)**

24. Gunsaria R.K. and Meena Ram Narayan, Studies of Cationic Micelles on Photogalvanic Cells for Solar Energy Conversion and Storage. *Int. J. Bio. and Applied Chem. Sci.,* **2(1),** 77 **(2012)**

25. Nair Smita, A Study of Transition Metal Complex of Diuretic Drug and study of its Phyco-chemical properties as Potential Therapeutic Agent. *Res. J. Recent Sci.,***1(ISC-2011),** 341 **(2012)**

26. Mohan Lal and Gangotri K.M. A Comparative study the performance of photogalvanic cells with mixed surfactant for solar energy conversion and storage: D- Xylose – Methylene Blue system. *Res. J. Recent Sci.* **2(12)**,19, **(2013)**

27. Gangotri KM, Lal Mohan. Study of photogalvanic effect in photogalvanic cell with mixed surfactant for solar energy conversion and storage. *Res. J. Chem.Sci.,* **3(3)**:20 **(2013)**

28. Lal Mohan, Gangotri KM. Study on the Performance of photogalvanic cell with mixed surfactant for solar energy conversion and storage. *Res. J. Recent Sci.,* **(isc2012)**, 76 **(2013)**

29. Rathore Jayshree and Lal Mohan, Studied on Study of photogalvanic effect in photogalvanic cell containing single surfactant as DSS, tartrazine as a photosensitizer and EDTA as reductant for solar energy conversion and storage, *Res. J. Chem. Environ.,* **22 (6)** 53 **(2018)**

30. Rathore Jayshree, Pareek Rajesh Kumar and Singh Kewal Significance of Aniline blue in liquid phase dye sensitized Photo Galvanic cell for Solar power generation and Storage by using Ascorbic acid and Sodium Lauryl Sulphate chemicals, *Res. J. Chem. Environ.,* **26(3)** 45 **(2022)**