Study in Cationic Micellar Effect on Photogalvanics: Cetyl Pyridinium Chloride- Ethylene Diamine Tetra Acetic Acid – Safranine O System for Solar Energy Conversion and Storage

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Abstract: The Object of the Study is to observe the enhancement on photogalvanics in presence of cationic micellar species i.e. cetyl pyridinium chloride in photogalvanic cell for solar energy conversion and storage. The photogalvanic system provides the higher values in maximum current value 225.0 μA as compare to 15.0 μA in without micellar system. The power at power point of the cell is 28.12 μW as compare to 3.00 μW and storage capacity of cationic micellar system is 25.0 min. as compare to 11.0 minutes in without micellar photogalvanic cell. The conversion efficiency and i-V characteristics of the cells have been determined and a mechanism has also been proposed for the generation of electricity in photogalvanic cells having cationic micellar species and without micellar system.

Keywords: Photogalvanic cell, Storage capacity, Conversion efficiency, Photocurrent, Fill Factor.

1. INTRODUCTION

The flow of current was observed between the two unsymmetical illuminated metal electrodes in sunlight by Becquerel [1] in 1839. The conventional sources of energy are creating pollution along with depleting at very high rate; hence it became compulsion of the scientific community to find out the non-conventional source of energy. Among the renewable sources, scientists have focused on solar energy because of its high promising and non-polluting nature along with abundantly availability without any hazard. In this respect, the photogalvanic cells were first of all reported by Rideal and Williams [2] but systematically investigated by Rabinowitch [3-4] whereas Weber and Matijevic [5] have reported the inhibition of photogalvanic phenomena. Later on, Porter and Thaller [6] have observed the efficiency of some iron-thionine photogalvanic cells and Gomer [7], Clark and Eckert [8] have also reported some photogalvanic cells with good results. Kaneka and Yamada [9] have observed photopotential and photocurrent induced by a tolusafranine ethylene diamine tetra acetic acid system. Osif *et al.* [10] have studied the kinetics of dark back reaction of products of the photoreduction of triplet thionine by iron (II) evidence of association of leucothionine and semithionine with iron (III) whereas Riggs and Bricker [11] have studied in irreversible photogalvanic cell using iron (III) and iron (II) oxalate and Sinha [12] has reported photoelectrochemical devices. Memming [13] has also reported solar energy conversion by photoelectrochemical processes whereas some good photogalvanic systems have been reported by Ameta *et al.* [14], Gangotri and Lal [15], lal and Gangotri [16] Archer and Ferreira [17], Hann *et al.* [18], Alwi *et al.* [19], Singahara *et al.* [20], Koli [21], and Koli *et al.* [22] whereas Yamada *et al.* [23], Witzke [24], and Deb [25], have their patents on solar energy conversion and storage.

Gangotri and Bhimwal [26], Srivastava *et al.* [27] and Bhowmik *et al.* [28] have used surfactants in photogalvanic cell for solar energy conversion and storage whereas Dung and Kozak [29], O'Regan and Gratzel [30], Hoffman and Lichtin [31], Albery and Archer [32], Kamat *et al.* [33] and Gangotri and Koli [34] have determained the efficiency of photogalvanic systems. Kettani [35] has also reported the solar energy conversion into electricity and Keller *et al.* [36] have proposed the mechanism of photogalvanic effect whereas Boltan [37] has described the historical perspective on photochemical conversion and storage of solar energy.

Recently Gangotri and Gangotri [38-41] have studied the micellar effect on photogalvanics for solar energy conversion and storage through photogalvanic cells containing different nature of micelles and Malviya and Solanki [42] have meticulously reviewed the field of photogalvanics as sustainable and promising device for solar energy conversion and storage.

The purpose of article is to study the usefulness of cationic micellar effect on photogalvanics for solar energy conversion storage with special reference to determine the extent of enhancement in electric output and storage capacity of photogalvanic cell. In the

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E-ISSN: 1929-6002/17

present research work, the cetyl pyridinium chloride (CPC) acts as caionic micellar species and resulted into higher amount of electrical output as well as storage capacity both, in comparison to without micellar system. It is because; the CPC micelle have solubilized the used dye molecules up to the maximum extent and stabilized the system as a whole.

2. MATERIALS AND METHODS

2.1. Materials

The following materials are used in the present work (Table **1**).

2.2. Method

An H-shaped glass tube is fabricated and darkened keeping a window in one of the arm to make it illuminated chamber and other arm as dark chamber. The known amounts of solutions of cetyl pyridinium chloride (cationic micelles), ethylene diamine tetra acetic acid as reductant, safranine O as photosensitizer and sodium hydroxide to maintain the pH of system, are filled in this H-shaped tube. A doubly distilled water is added to make up 25.0 ml. of total volume of the solutions in all the sets of experiments. The platinum electrode having dimension 1.0 x 1.0 cm^2 is dipped before the window in one arm and a saturated calomel electrode working as reference electrode is dipped in another arm of the H-shaped glass tube. A tungsten lamp of 200 W is placed in front of platinum electrode. The terminals of the electrodes (Pt & SCE) are connected to a digital pH meter and micro-ammeter through a key and resistance to measure the photopotential and photocurrent generated in the photogalvanic system, by keeping one circuit open and other closed with the help of a key. A water filter is placed between the illuminated chamber and light source to cut-off the infra-red radiations. The whole system is kept in dark until a stable potential is attained and then a light source is used in front of platinum electrode and a maximum potential as photopotential and a photocurrent generated are measured in the system. The current-voltage characteristics have been studied by applying an external load with the help of a carbon pot (log 470 K) connected in the circuit. The error in observed values of potential (from digital pH meter) and current (from micro-ammeter) are ± 5 mV and ± 10 μA, respectively. The i-v characteristics have been studied by applying the external load with the help of carbon pot (log 470 k) to vary the current values and measured the corresponding potentials. To obtain the power of the cells, current and potential values are multiplied. The power at power point of the cell is also

Chemicals

Table 1: Materials

	Chemicals	Specification	Purity	Conc. of soln
1	Celyl Pyridinium Chloride (cationic micelles)	LOBA	Purity 95.8%	M/100
2	Ethylene Diamine Tetra Acetic acid (EDTA) (Reductant)	Qualigens	99.5%	M/100
3	Safranine O (Photosensitizer)	Ases	95 % dye content	M/500
4	Sodium hydroxide	Ranbaxy	98% Assay	1M
5	Oxalic acid	Qualigens	97% purity	1M
6	Phenolphthalein	Merck	98%	1M

Equipments

	Apparatus	Specification
1	Digital pH meter	Systronics Model-335
2	Micro-ammeter	Ruttonsha Simpson
3	Saturated calomel electrode	Toshniwal
4	Solar light intensity meter	Solarimeter model-501 cell
5	Light source- 200 W, tungsten lamp	Sylvania
6	Carbon pot (log 470 K)	murphy

determined by getting the highest product of these two values. The used experimental set up is shown in Figure **1**.

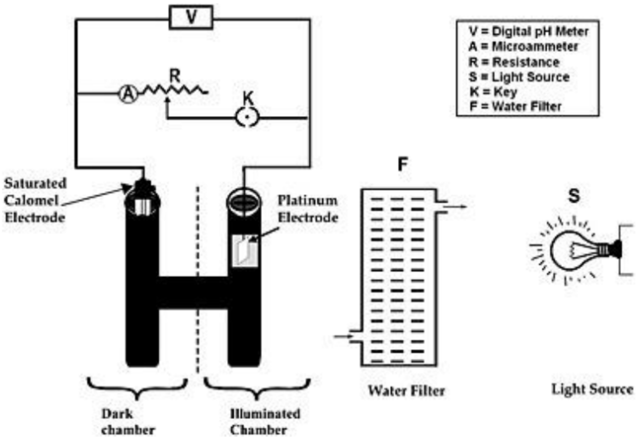

Figure 1: Experimental Set up.

3. RESULTS AND DISCUSSION

The effect of cationic micellar effect on photogalvanics has been studied in photogalvanic cell containing cetyl pyridinium chloride (CPC) as cationic micellar species, ethylene diamine tetra acetic acid (EDTA) as reductant and safranine O as photosensitizer in the photogalvanic system. The cationic micellar effect on photogalvanics has been observed on various parameters and the results are summarized in the tables as given below with different variations.

3.1. Effect of Variation of CPC Concentration

It is observed that on variation of cetyl pyridinium chloride (CPC) concentration, the electrical output is highest around the critical micelles concentration of used micellar species (CPC). The observed results are summarized in Table **2**.

3.2. Effect of Variation of EDTA Concentration

The EDTA is working as reductant, transferring electron to the photosensitizer-Safranine O, converting it to semi or leuco form which is in turn transferring the electron to the electrode and ultimately flow of electrons comes in to picture. It is observed that on increasing the concentration of EDTA (reductant) the electrical output increased and reached to a maximum value at particular concentration and then decreased. The trend of results are due to lesser number of reductant molecules are available to donate electron to the photosensitizer at lower concentration and at the higher concentration of reductant the large number of molecules hinder the moment of photosensitizer to reach the electrode. The obtained results are summarized in Table **3**.

Table 2: Effect of Variation of CPC Concentration

[CPC] = 6.00 x 10^{-3} M
pH = 12.68
Temp. = 303 K

[Safranine O] = 4.64 x 10^{-5} M
Light intensity = 10.4 mWcm^{-2}
Electrode = 1.0 x 1.0 cm^2

	CPC -EDTA-Safranine O	**[CPC] x 10^{-3} M**				
	System	**5.60**	**5.80**	**6.00**	**6.20**	**6.40**
1.	Dark Potential (mV)	214.0	142.0	166.0	181.0	238.0
2.	Open cir. Volt. Voc (mV)	794.0	840.0	913.0	883.0	856.0
3.	Photoptential ΔV (mV)	580.0	698.0	747.0	702.0	618.0
4.	Max. Photocur. i_{max} (μA)	181.0	196.0	225.0	180.0	171.0
5.	Short cir.cur. i_{eq} (μA)	40.0	62.0	80.0	45.0	25.0
6.	Power of the Cell (μW)	23.24	43.27	59.76	31.59	15.45
7.	Ini. Gene. of Cur. (μA min^{-1})	18.10	19.60	28.12	18.00	17.10
8.	Pot. at p. point Vpp (mV)	283.0	310.0	382.0	291.0	222.0
9.	current at p. point ipp (μA)	15.0	29.0	40.0	23.0	16.0
10.	Power at p. point (μW)	4.24	8.99	15.28	6.69	3.55
11.	fill factor (n)	0.1336	0.1726	0.2092	0.1684	0.1659
12.	Conversion Efficiency (%)	0.4081	0.8644	1.4692	0.6435	0.3415
13.	Storage Capacity $t_{1/2}$ (min.)	14.0	15.0	25.0	19.0	11.0
14.	Charging time (min.)	140.0	135.0	120.0	140.0	140.0

Table 3: Effect of Variation of EDTA Concentration

[CPC]= 6.00 x 10^{-3} M
[Safranine O] = 4.64 x 10^{-5} M
pH = 12.68
Light intensity = 10.4 mWcm^{-2}
Temp.= 303 K
Electrode = 1.0 x 1.0 cm^{2}

	CPC-EDTA-Safranine O	**[EDTA] x 10^{-3} M**				
	System	**2.20**	**2.22**	**2.24**	**2.26**	**2.28**
1.	Dark Potential (mV)	210.0	260.0	166.0	283.0	240.0
2.	Open cir. Volt. Voc (mV)	805.0	868.0	913.0	850.0	803.0
3.	Photoptential ΔV (mV)	595.0	608.0	747.0	617.0	563.0
4.	Max. Photocur. i_{max} (μA)	145.0	178.0	225.0	168.0	138.0
5.	Short cir.cur. i_{eq} (μA)	19.0	43.0	80.0	48.0	38.0
6.	Power of the Cell (μW)	11.30	26.14	59.76	29.61	21.39
7.	Ini. Gene. of Cur. (μA min^{-1})	14.50	17.80	28.12	16.80	13.80
8.	Pot. at p. point Vpp (mV)	191.0	211.0	382.0	260.0	241.0
9.	current at p. point ipp (μA)	13.0	16.0	40.0	21.0	14.0
10.	Power at p. point (μW)	2.48	3.37	15.28	5.46	3.37
11.	fill factor (n)	0.1623	0.0904	0.2092	0.1338	0.1105
12.	Conversion Efficiency (%)	0.2387	0.3246	1.4692	0.5250	0.3244
13.	Storage Capacity $t_{1/2}$ (min.)	17.0	22.0	25.0	18.0	13.0
14.	Charging time (min.)	132.0	140.0	120.0	140.0	140.0

3.3. Effect of Variation of Safranine O Concentration

The photosensitizer (Safranine O) working to transfer the electron and continuing the flow of the electron in to the system. It is observed that the electrical output, conversion efficiency and storage capacity is increased and reaches a maxima at the particular concentration and then again decreased. On illumination, Safranine O molecules get excited and came into the process of electron accepting form reductant and donating to the electrode and flow of electron takes place. It is observed that a lower concentration of Safranine O, small number of

Table 4: Effect of Variation of Safranine O Concentration

[CPC]= 6.00 x 10^{-3} M
[EDTA] = 2.24 x 10^{-3} M
pH = 12.68
Light intensity = 10.4 mWcm^{-2}
Temp. = 303 K
Electrode = 1.0 x 1.0 cm^{2}

	CPC -EDTA-Safranine O	**[Safranine O] = 4.64 x 10^{-5} M**				
	system	**4.48**	**4.56**	**4.64**	**4.72**	**4.80**
1.	Dark Potential (mV)	106.0	105.0	166.0	83.0	155.0
2.	Open cir. Volt. Voc (mV)	716.0	806.0	913.0	809.0	698.0
3.	Photoptential ΔV (mV)	610.0	701.0	747.0	692.0	543.0
4.	Max. Photocur. i_{max} (μA)	162.0	180.0	225.0	213.0	178.0
5.	Short cir.cur. i_{eq} (μA)	54.0	64.0	80.0	68.0	52.0
6.	Power of the Cell (μW)	32.94	44.86	59.76	47.05	28.23
7.	Ini. Gene. of Cur. (μA min^{-1})	16.20	18.00	28.12	21.30	17.80
8.	Pot. at p. point Vpp (mV)	286	301	382	315	278
9.	current at p. point ipp (μA)	28.0	31.0	40.0	33.0	26.0
10.	Power at p. point (μW)	8.00	9.33	15.28	10.39	7.228
11.	fill factor (n)	0.2071	0.2079	0.2092	0.1696	0.1992
12.	Conversion Efficiency (%)	0.7700	0.1808	0.4692	0.9995	0.6950
13.	Storage Capacity $t_{1/2}$ (min.)	18.0	21.0	25.0	21.0	15.0
14.	Charging time (min.)	120.0	125.0	120.0	115.0	130.0

Table 5: Effect of Variation of pH

[CPC]=6.00 x 10^{-3} M
[EDTA] = 2.24 x 10^{-3} M
[Safranine O] = 4.64 x 10^{-5} M
Light intensity = 10.4 $mWcm^{-2}$
Temp. = 303 K
Electrode = 1.0 x 1.0 cm^2

	CPC -EDTA-Safranine O	pH				
	System	**12.60**	**12.64**	**12.68**	**12.71**	**12.74**
1.	Dark Potential (mV)	290	272	166	145	184
2.	Open cir. Volt. Voc (mV)	830	890	913	845	727
3.	Photoptential ΔV (mV)	510	618	747	780	543
4.	Max. Photocur. i_{max} (μA)	168	181	225	190	154
5.	Short cir.cur. i_{eq} (μA)	50	63	80	67	52
6.	Power of the Cell (μW)	25.50	38.93	59.76	47.16	28.23
7.	Ini. Gene. of Cur. (μA min^{-1})	16.8	181.1	28.12	19.0	15.4
8.	Pot. at p. point Vpp (mV)	187	201	382	218	151
9.	current at p. point ipp (μA)	16	21	40	23	18
10.	Power at p. point (μW)	2.99	4.22	5.28	5.01	2.71
11.	fill factor (n)	0.0239	0.0752	0.2092	0.4058	0.0718
12.	Conversion Efficiency (%)	0.2876	0.4058	1.4692	0.0885	0.2613
13.	Storage Capacity $t_{1/2}$ (min.)	11	18	25	19	13
14.	Charging time (min.)	135	110	120	120	120

photosensitizer molecules are available for excitation and consecutive electron transfer whereas higher concentration of Safranine O also resulted into the lowering of photopotential, photocurrent because the major portion of the light is absorbed. The results are summarized in Table **4**.

3.4. Effect of Variation of pH

On variation of pH on the system, it is observed that at particular pH the maximum electrical output is obtained. The determined working range of pH is 12.60-12.74. It was observed that pH for optimum condition for reductant has a relation with its pKa value i.e. the desire pH should be slightly higher than their pKa values (pH>pKa). The reason may be the availability of reductant in its anionic form, which is better donor form. The results are summarized in Table **5**.

3.5. Effect of Variation of Temperature

It is observed that there is increase in photocurrent values on increasing temperature of photogalvanic system with a rapid fall in photopotential values. The results are summarized in Table **6**.

3.6. Effect of Variation of Light Intensity

It is observed that photocurrent is increased linearly where as the photopotential increased in logarithmic way. The results are summarized in Table **7**.

Table 6: Effect of Variation of Temperature

[CPC]= 6.00 x 10^{-3} M
[EDTA] = 2.24×,10-−3. M
[Safranine O] = 4.64 x 10^{-5} M
Light intensity = 10.4 $mWcm^{-2}$
pH = 12.68
Electrode = 1.0 x 1.0 cm^2

CPC -EDTA-Safranine O	Temperature K				
system	**298.0**	**303.0**	**308.0**	**313.0**	**318.0**
Photopotential (mV)	788.0	747.0	698.0	641.0	588.0
Photocurrent (μA)	42.0	54.0	68.0	88.0	92.0
Power (μW)	33.09	40.33	47.46	51.28	54.09

Table 7: Effect of Light Intensity

[CPC]= 6.00 x 10^{-3} M	[EDTA] = 2.24 x 10^{-3} M
[Safranine O] = 4.64 x 10^{-5} M	Temp. = 303 K
pH = 12.68	Electrode = 1.0 x 1.0 cm^2

CPC -EDTA-Safranine O	Light Intensity ($mWcm^{-2}$)				
system	3.1	5.2	10.4	15.6	26.0
Photopotential (mV)	696.0	712.0	747.0	772.0	828.0
Photocurrent (μA)	68.0	71.0	80.0	88.0	104.0
LogV	2.842	2.852	2.873	2.887	2.918

Table 8: Effect of Electrode Area

[CPC]= 6.00 x 10^{-3} M	[EDTA] = 2.24 x 10^{-3} M
[Safranine O] = 4.64 x 10^{-5} M	Temp. = 303 K
pH = 12.68	Light intensity = 10.4 $mWcm^{-2}$

CPC -EDTA-Safranine O	Electrode x cm^2				
system	0.6	0.8	1.00	1.2	1.3
Maximum Photocurrent i_{max} (μA)	193.0	208.0	225.0	241.0	254.0
Equilibrium Photocurrent i_{eq} (μA)	71.0	77.0	80.0	84.0	89.0

3.7. Effect of Variation of Electrode Area

The observed results on variation of electrode area in photogalvanic cell containing CPC-EDTA-Safranine O system show the increasing the electric output as the electrode size is increased, it is perhaps the increase in number of strikes of electrons. The results are summarized in Table **8**.

3.8. Current- Voltage Characteristics of the Cell

The observed enhancement in electrical output, conversion efficiency and storage capacity in CPC-EDTA- Safranine O- system of phtogalvanic cell are determined by applying external load on the circuit by carbon pot (log 470 K). The results are summarized in the Table **9**.

3.9. Conversion Efficiency

The electrical output, initial generation of current, power at power point, maximum current, conversion efficiency and storage capacity of the photogalvanic cell containing cationic micellar species have been enhanced. The system still requires the proper selection of redox couple as well as the proper micellar species in system to get the desired results with respect to the remarkable conversion efficiency and storage capacity along with lower down its cost for their viability. The results are summarized in Table **10**.

Table 9: i-v Characteristics of Cell

[CPC]=6.00 x 10^{-3} M	[EDTA] = 2.24 x 10^{-3} M
[Safranine O] = 4.64 x 10^{-5} M	Temp. = 303 K
pH = 12.68	Electrode = 1.0 x 1.0 cm^2

Current (μA)	Potential* (mV)	Power (μW)
0.0	747.0	0.00
5.0	703.0	3.51
10.0	627.0	6.27
15.0	578.0	8.67
20.0	549.0	10.98
25.0	505.0	12.62
30.0	473.0	14.19
35.0	418.0	14.63
40.0	382.0	15.28
45.0	322.0	14.49
50.0	275.0	13.75
55.0	203.0	11.16
60.0	170.0	10.20
65.0	155.0	10.07
70.0	141.0	9.87
75.0	73.0	5.47
80.0	0.0	0.00

*Absolute Value.

Table 10: Solar Conversion Data

[CPC]=6.00 x 10^{-3} M [EDTA] = 2.24 x 10^{-3} M

[Safranine O] = 4.64 x 10^{-5} M Temp. = 303 K

pH = 12.68 Electrode = 1.0 x 1.0 cm^2

	CPC-EDTA-Safranine O	**Light Source**	**Sunlight**
	System	**(10.4 $mWcm^{-2}$)**	**(100.0 $mWcm^{-2}$)**
1.	Open Circuit Voltage Voc (mV)	913.0	2310.0
2.	Maximum Photocurrent i_{max} (μA)	225.0	590.0
3.	Short circuit current i_{sc} (μA)	80.0	230.0
4.	Photopotential ΔV (mV)	747.0	1569.0
5.	Power of Cell (μW)	59.76	360.87
6.	Power at power point (μW)	15.28	33.17
7.	Fill Factor (n)	0.2092	0.6128
8.	Conversion Efficiency (%)	1.4692	3.8139

Table 11: Cationic Micellar Effect on Photogalvanics

[CPC]= 6.00 x 10^{-3} M [EDTA] = 2.24 x 10^{-3} M

[Safranine O] = 4.64 x 10^{-5} M Temp. = 303 K

pH = 12.68 Electrode = 1.0 x 1.0 cm^2

System	**V_{oc} (mV)**	**i_{sc} (μA)**	**ΔV (mV)**	**Power of The cell (μW)**	**Power at Power Point (μW)**
Cationic micelles	913.0	80.0	747.0	59.76	15.28
Without micelles	884.0	100.0	564.0	56.4	3.00

System	**i_{max} (μA)**	**Rate of Initial generation of current**	**Conversion Efficiency (%)**	**Fill factor (n)**	**$t_{1/2}$ (Min.)**
Cationic micelles	225.0	28.12	1.4692	0.21	25.0
Without micelles	15.0	4.25	0.0312	0.03	11.0

3.10. Performance of the Photogalvanic Cell

The overall performance of the photogalvanic cell has been studied by determining i-V characteristics. On the basis of observations the power at power point of the cell is determined as 15.28 μW and the fill factor as 0.2092 by using the following formula (3.1 and 3.2) respectively.

$$\text{power at power point} = V_{pp} \times i_{pp} \qquad (3.1)$$

$$\text{fill factor} = \frac{Vpp \times ipp}{Voc \times isc} \qquad (3.2)$$

The conversion efficiency is determined by using the formula (3.3)

$$\text{conversion efficiency} = \frac{Vpp \times ipp}{10.4 mWcm^2 \times A} \qquad (3.3)$$

The value of observed conversion efficiency is 0.1469%. The photogalvanic cell so developed is working for 25.0 minutes in dark on illuminating for 120.0 minutes (the charging time).

3.11. Cationic Micellar Effect on Photogalvanics

The photogalvanic systems have been developed in presence of cationic micellar species i.e. cetyl pyridinium chloride (CPC) and in absence of cationic micellar species (without micelles). The observed results are clearly indicating the enhancement in electrical output as well as storage capacity of photogalvanic cell containing cationic micellar species in comparison to system without micellar species The results are summarized in Table **11**.

In view of the results obtained, the overall efficiency of the cells containing different types of the micelles, has the order as given below-

Anionic micelles > Neutral micelles > Cationic micelles > without micelles

4. MECHANISM

A mechanism has also been proposed for the generation of photocurrent in the photogalvanic system on the basis of observed results which is given below:-

Illuminated Chamber

The dye molecules (Safranine O- Saf O) get excited to its singlet state and inter system crossed to its triplet state on illumination

$$\text{Saf O} \xrightarrow{h\nu} \text{Saf O *(Excited)}^{1} \xrightarrow{\text{ISC}} \text{Saf O*(Excited)}^{3} \quad (1)$$

The excited Saf O molecules accept an electron from reductant and get converted into semi or leuco form of Saf O dye, and the reductant gets converted to its oxidized form

$$\text{Saf O*(Excited)}^{3} + \text{R} \longrightarrow \underset{\text{(Semi or leuco)}}{\text{Saf O}^{-}} + \text{R}^{+} \quad (2)$$

(R-Reductant) (R^{+}- Oxidized reductant)

At Platinum Electrode

The semi or leuco form of Saf O^{-} dye loses an electron and converted into original Saf O dye molecule.

$$\text{Saf O}^{-} \longrightarrow \text{Saf O} + e^{-} \quad (3)$$

Dark Chamber

At Counter Electrode

Dye molecule accepts an electron from electrode and converted in semi or leuco form

$$\text{Saf O} + e^{-} \longrightarrow \text{Saf O}^{-} \quad (4)$$

Finally leuco/semi form of Saf O dye and oxidized reductant combine to produce original Saf O dye and reductant molecule and the cycle will go on

$$\text{Saf O}^{-} + \text{R}^{+} \longrightarrow \text{Saf O} + \text{R} \quad (5)$$

5. CONCLUSION

Conclusively the electrical output, initial generation of current, power of the cell, power at power point of cell, maximum current and storage capacity of the photogalvanic cell containing cationic micellar species have been enhanced in comparison to the photogalvanic cells without micelles in system. The storage capacity has been enhanced more than the double comparatively. The object of the research article is enhancement in the overall results by using cationic micelles. The results obtained are proving it because cationic micelles have solubilized the dye molecules up to the maximum extent and stabilized the whole system. In view of the experimentation, the photogalvanic system should have the micellar species irrespective of their type. Though, the conversion efficiency almost equal but the storage has edge over the drawback. The system still requires the proper selection of redox couple as well as the proper micellar species in system to get the desired results for its viability.

ACKNOWLEDGEMENT

The authors, especially Prerna Gangotri is thankful to UGC, New Delhi for award of Post-Doctoral Fellowship with financial assistance and Prof. P.K. Sharma (B), Head, Department of Chemistry for providing all facilities in the Department. Authors are also thankful to Prof. (Dr.) Sangeeta Loonkar for fruitful discussion.

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Received on 06-06-2017 Accepted on 19-06-2017 Published on 29-09-2017

DOI: https://doi.org/10.6000/1929-6002.2017.06.02.4