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Role of Alizarin red-S-NaLS-Ascorbic acid System in Solar Photogalvanic Performance and Storage

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ABSTRACT

The aim of research work was to convert and store the photogalvanic energy by alizarin red-s-NaLS-ascorbic acid. The photogalvanic cells are based on photoelectrochemical nature. This study is better over reductant system i.e., ascorbic acid. The obtained results are comparatively better for sustainable application. M/5000 solution of alizarin red-S, M/1000 solution of NaLS and M/1000 solution of ascorbic acid were used for experimental observation. The fill factor (FF) and conversion efficiency (CE) were calculated for alizarin red-S-NaLS-ascorbic acid system and results were 0.2731 and 1.8970%, respectively. The electrical outcome was relevant to power, open- circuit voltage, and short circuit current for alizarin red-S-NaLS-ascorbic acid system in solar photogalvanic performance and storage. These results are 197.29liW, 1075mV, 672^A, respectively. The photo-excitation of alizarin red-S molecules was studied in solar performance and storage for photoelectrochemical process.

Keywords: Photoelectrochemical, Excitation, Alizarin red-S, Performance, Conversion efficiency, Ascorbic acid.

INTRODUCTION

Energy is key component biosphere as living standard. Energy is needed for almost anything and everything in life. Consumption of energy is one of the indices in determine the levels of development of a nation. Therefore, availability of crucial for its development. Sunlight is best light source for in alizarin red-S-NaLS-ascorbic acid system in photogalvanic performance and storage. The photogalvanics are photoelectrochemical (PEC) systems based on[1,2] current flow of the sunlight (Becquerel,1839). These PEC systems are reported for photo[3] galvanic (PG) effect for sustainability (Rideal and Williams,1925).

The photogalvanics are photoelectrochemical properties (PEP) about the iron-thionine component for characteristics about electrochemical nature[4-5] (Rabinowitch, 1940). Later on, various researchers[6-9] (Clark and Eskert, 1975; Suda, *et at.,* 1978; Fox, *et at.,* 1979; Stevenson and Ervelding, 1981) studied some challenging results for synthesis of technological products.

Later on, Solar energy parameters were discussed for various problems, that's encountered in the development of the this field[10] (Hoffman and Lichtin, 1979). The used of dye reductant with surfactants in PG cells for faster and fairer solar energy transformation and observed the comparative better PG effect[11-16] (Ameta *et al.,* 1989; Gangotri and Regar, 1997; Gangotri, *et al.,* 1999; Gangotri and Lal, 2000; Gangotri and Genwa, 2004; Gangotri, and Kumar, 2009, respectively).

Innovative study about PEC system in PG cell were studied by time to time for faster[17] and fairer results. In this order, DSS-tartrazine-EDTA were studied for fairer results (Rathore, and Lal, 2018). DSS-Tetrazine-EDTA system in PG cell for was studied for conversion efficiency (CE), t0.5 and fill factor (FF) and obtained results are 0.2800%, 100.0 minutes and 0.3024, respectively.

Most relevant research work about PG effect in various PEC system was studied for[18-21] scientific way about directing to dye reductant process (Genwa and Sonel, 2010; Genwa and Sagar, 2013; Genwa and Singh, 2013; Genwa and Singh, 2017) and some PG cells were developed22-23 (Koli, 2014; Koli and Sharma, 2016).

The natural dye-based surfactant combinations have used for PG cells for ecofriendly[24] environment (Rathore *et al.,* 2022). They have studied PG cell for lauryl glucoside-tartrazine- fructose and obtained results in the terms of the CE, t0.5 and FF were recorded as 0.5313%, 100.0 min and 0.5357, respectively. The PG Cells were also studied at various electrical scale i.e., photocurrent (PC), photopotential (PP), CE, FF and PG cell performance[25] (Rathore *et al.,* 2022).

They have obtained better results as given: 388.0liA, 1141.0mV, 0.7995%, 0.5389 and 129 min in terms of PC, PP, CE, FF and PG cell performance, respectively.

The progressive study about fairer and faster results for prospective energy source through photo-galvanic-system by using of mixed surfactants and subsequently, innovative research work for sustainable development for prospective energy source-based PG cell have been reported. For D-Xylose+MB+Brij-35+NaLS system, CE was observed 0.2812% and PGS performance was found for 120.00 min[26] (Lal and Gangotri, 2022). The D-Xylose+MB+Brij- 35+NaLS PGS for PG cell performance was 110.00 min in dark[27] (Lal and Gangotri, 2022).

The most relevant and recent research work has been reported by innovative study in renewable energy source through mixed surfactant system for eco-fr(Ldlyaretivironm ent Gangotri, 2023).

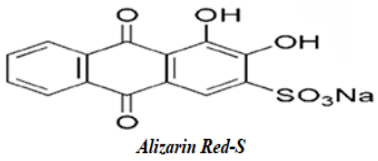
Therefore, present study was used in Alizarin red-s Ascorbic acid-sodium lauryl sulphate system as photosensitizer-reductant-anionic surfactant in strong basic medium. Study aims was to investigate the further electrical performance and optimum efficiency of dye- surfactant combination in photogalvanic cell system.

MATERIALAND METHODS

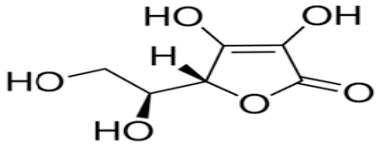
Materials and Experiments

Alizarin red-s dye (Surana scientific Pvt. Ltd., Jodhpur, India) as photosensitizer, Ascorbic acid (Loba Chemie Pvt. Ltd. Mumbai, India) as photo reductant, sodium lauryl sulphate (NaLS), (SISCO Research Laboratories-Mumbai) as surfactant and NaOH (Merck) as basic medium has been used in experimental work. Alizarin red-s dye is M.F. $C_{14}H_7NaO7S$, M.W.-342.26, Absorption spectra-530-560nm, solubility in water, an ethanol and colour-yellow-orange red powder, colour index number: 58005. These solutions were prepared at particular-3-5concentration range for faster and fairer results. The used concentrations were 10 M,10 M,and 10^{-3} M, for Ascorbic acid, Alizarin red-s and sodium lauryl sulphate, respectively. These solutions were prepared by distilled water and store in glass vessels to save them from

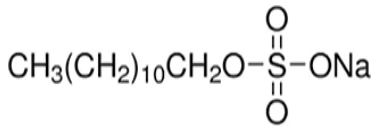
electromagnetic rays. A mixture of Alizarin Red-S-Ascorbic acid-NaLS and alkaline medium was used in PG cell, Fig.1[13,15,23,26,27] (Gangotri, *et al.,* 1999; Gangotri and Genwa, 2004; Koli and Sharma, 2016; Lal and Gangotri, 2022).



Alizarin Red-S



Ascorbic acid



NaLS

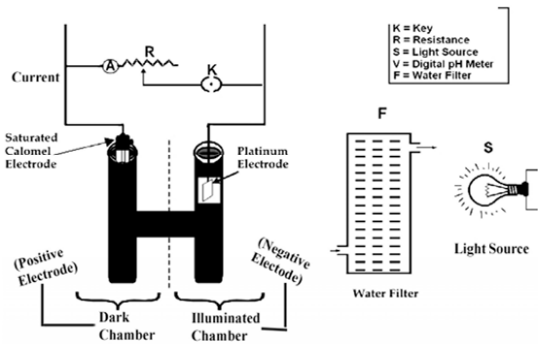


Fig. 1. Photogalvanic cell set-up

RESULTS AND DISCUSSION

Effect of variation of Alizarin Red-S (ARS) dye

The concentration of Alizarin Red-S was taken in variable nature, and its concentration ranges from 1.3X10'[5] M to 4.0X10'[5] M. The comparative better electrical outputs are obtained at 2.7X10^{-5} M. The alizarin red-S-NaLS-ascorbic acid system in solar photogalvanic performance and storage for potential, current and power were reported in Table 1 and Fig. 2. Initially, PP and PC increased on increase of Alizarin Red-S dye concentration and obtained the optimum peaks at 2.7X10^{-5} M, after optimum peaks, on further increase in the concentration of ARS, decrease in the electrical results. At the 1.3X10^{-5} M (lower concentration) of ARS there are only a few ARS molecules to absorb the major portion of the light and due to this, there was a low electrical output, while at 4.0X10^{-5} M (higher concentration) of ARS again resulted in decrease in electrical output[26,28] (Lal and Gangotri, 2022; 2023).

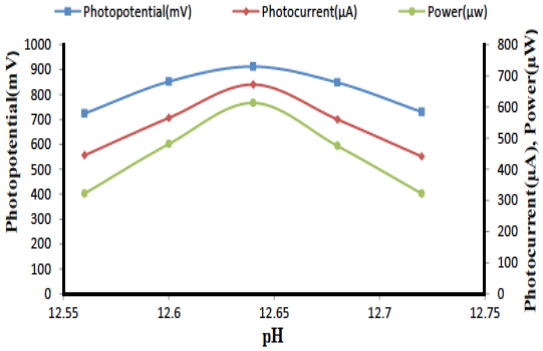


Fig. 2. Photopotential, photocurrent and power of PG cell

Table 1: Concentration of AR-Sx10^{-5} M with electrical output

Concentration of AR-S X 10^{-5} M	PP(mV)	PC(gA)	Power(gW)
1.3	734	438	321.49
2.0	862	567	488.75
2.7	912	672	612.86
3.4	870	574	499.38
4.0	728	440	320.32

Effect of variation of Ascorbic acid reductant

The ascorbic acid was taken in variable nature, and its concentration ranges from 2.04X10^{-3} M to 2.20X10^{-3} M. The comparative better results are obtained at 2.12X10^{-3} M. The alizarin red-S-NaLS-ascorbic acid system in solar photogalvanic performance and storage for potential, current and power were reported in Table 2 and Fig. 2. Initially, PP and PC are increased on increase of ascorbic acid concentration and obtained the optimum peaks at 2.12X10^{-3} M, after optimum peaks, on further increase in the concentration of AA, decrease in the electrical results. Its happed due to presence of ascorbic acid molecules for electron donation to ASR molecules. Higher molarity (2.20X10 M) of ascorbic acid resulted in decrease ascorbic acid molecules to reaching surface area of significant path.

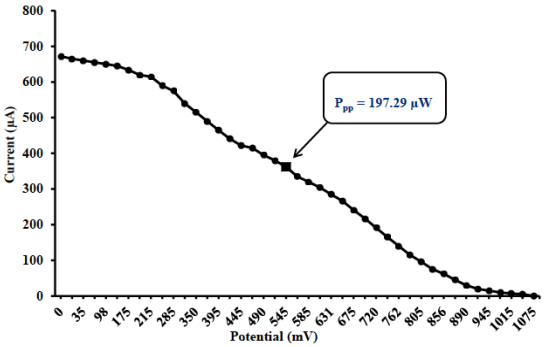


Fig. 3. i-V curve for the PG cell

Table 2: Concentration of A.A.x10M with electrical output

Concentration of A.A.X10^{-3} M	PP(mV)	PC(gA)	Power(gW)
2.04	725	446	323.35
2.08	818	580	474.44
2.12	912	672	612.86
2.16	824	584	481.21
2.20	720	452	325.44

Effect of variation of (NaLS) surfactant

The concentration of surfactant was taken in variable nature, and its concentration ranges from 3.2X10^{-3} M to 4.8X10^{-3} M. the comparative better results are obtained at 4.0X10^{-3} M. The alizarin red-S-NaLS-ascorbic acid system in solar photogalvanic performance and storage for potential, current and power were given in Table 3 and Fig. 2. Initially, PP and PC both are increased on increase of NaLS concentration and obtained the optimum peaks at 4.7X10 M, after optimum peaks, on further increase in the NaLS concentration, electrical output was[27] decreased in the uniform pathway of PG cell (Lal and Gangotri, 2022).

Table 3: Concentration of NaLSx10M with electrical output

Concentration of NaLSx10^{-3}M	PP(mV)	PC(gA)	Power(gW)
2.8	740	436	322.64
3.2	848	568	481.66
3.6	912	672	612.86
4.0	852	574	489.04
4.4	735	430	316.05

Effect of variation of pH

The pH of alizarin red-S-NaLS-ascorbic acid was taken in strong alkaline medium, its ranges from 12.56 to 12.72. the comparative better results are obtained at 12.64. The alizarin red-S-NaLS-ascorbic acid system in solar photogalvanic performance and storage for potential, current and power were reported in Table 4. Initially, PP and PC increased on increase of pH and obtained the optimum peaks, after optimum peaks, on further increase in the pH,[24,25] electrical output was decreased in the uniform pathway of PG cell (Rathore *et al.,* 2022).

Table 4: pH with electrical output

PI	PP(mV)	PC(gA)	Power(gW)
12.56	724	445	322.18
12.60	852	565	481.38
12.64	912	672	612.86
12.68	848	560	474.88
12.72	730	441	321.93

Characteristics of the PG cell (current-voltage, i-v)

The PG cell containing alizarin red-S-NaLS-ascorbic acid system, the (i-v)[18,22,23,26] characteristics of the cell was significantly reported for charging of the cell (Genwa, and Sonel, 2010; Koli, 2014; Koli and Sharma, 2016; Lal and Gangotri, 2022) and the FF was calculated by the following formula[11,12,13,15,27] (Ameta *et al.,* 1989; Gangotri and Regar, 1997; Gangotri *et al.,* 1999; Gangotri and Genwa, 2004; Lal and Gangotri, 2022).

$$FF = (\eta)\frac{Vpp \times ipp}{Voc \times isc} \quad (1)$$

The alizarin red-S-NaLS-ascorbic acid system in solar photogalvanic performance and storage for i-v (current - voltage) characteristics were shown in Table 5 and Figure 3.

Table 5: (I-V) Characteristic table of the Alizarin red-S-NaLS-ascorbic acid

Potential (mV)	Current (gA)	Power (gW)	FF
1075	0	0	
1046	5	5.23	
921	20	18.42	
890	30	26.70	
874	45	39.33	
805	96	77.28	
784	115	90.16	
762	140	106.68	
631	285	179.83	
615	304	186.96	
585	320	187.20	
545(Vpp)	^{362}(ipp)	197.29(pp)	0.2731
514	380	195.32	
420	441	185.22	
395	465	183.67	
215	615	132.22	
175	634	110.95	
98	650	63.70	
8	668	5.34	
0	672	0	

Cell performance and conversion efficiency

The alizarin red-S-NaLS-ascorbic acid system in solar photogalvanic performance was obtained in term of half-life periods (t1/2) and its value was 140 minutes. The alizarin red-S-NaLS-ascorbic acid system in solar photogalvanic performance was reported in Table 6. The CE of the PG cell was calculated by the formula[11,12,13,15,24,27] (Ameta *et al.,* 1989; Gangotri and Regar, 1997; Gangotri *et al.,* 1999; Gangotri and Genwa, 2004; Rathore *et al.,* 2022, Lal and Gangotri, 2022) and obtained value was 1.8970%.

$$CE = \frac{V_{pp} \times i_{pp}}{A \times 10.4\ MW\ cm\text{-}2} \times 100\% \quad (2)$$

Where V_{pp}= power point photopotential
I_{pp}= power point photocurrent
A=electrode area respectively.

Table 6: Study of PG Cell Performance

Time (min)	Power (gW)
0	197.29
10	190.36
20	183.41
30	175.76
40	168.11
50	162.46
60	155.14
70	148.30
80	142.51
90	134.18
100	126.40
110	120.24
120	113.16
130	105.86
140 (ti/2)	98.64 (TJ/2)
150	92.50
160	85.33
170	78.48
180	70.28

#For table no 1 to 6, Light intensity=10.4 mWcm, Platinum electrode=1.0x1.0cm' Temperature =303K,

Mechanism

The alizarin red-S-NaLS-ascorbic acid system in solar photogalvanic performance and storage be may be proposed as follows:

Illuminated chamber

$$AR\text{-}S \longrightarrow AR\text{-}S \quad (3)$$

$$AR\text{-}S^{*}+R \longrightarrow AR\text{-}S\text{-}+AA+ \quad (4)$$

At platinum electrode

$$AR\text{-}S\text{-} \longrightarrow AR\text{-}S+ e\text{-} \quad (5)$$

Dark chamber
At counter electrode

$$AR\text{-}S+e^{-} \longrightarrow AR\text{-}S\text{-} \quad (6)$$

$$AR\text{-}S\text{-}+R^{+} \longrightarrow AR\text{-}S + R \quad (7)$$

Where AR-S, AR-S-, R and R+ are the Alizarin red-s, its leuco form, Ascorbic acid and its oxidized form, respectively.

CONCLUSION

The alizarin red-S-NaLS-ascorbic acid system in solar photogalvanic performance and storage be may be proposed for industrial applications. The Alizarin red-s as dye photosensitizer, Ascorbic acid as reductant and NaLS as surfactant combination in PG cell are better for PG cells. PG cells having inbuilt storage capacity and ecofriendly in nature. The low-cost materials are used in these cells. The fairer CE, t0.5 and FF are recorded as 1.8970%, 140.00 min and 0.2731, respectively. The very diluted solution (AR-S X 10^{-5} M) were used in PG cell, which favour to ecofriendly environment also. Alizarin Red-S-NaLS-ascorbic acid photogalvanic cells system shows good prospects for commercially viable.

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Conflicts of interest

All Authors have no any conflict of interest.

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