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# Photo galvanic cells that transform and store solar Energy use ionic liquid as an electrolyte

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## Abstract:

In photo galvanic cells, the ionic liquid 1-butyl-3-methylpyridinium bis-trifluoromethylsulfonyl) imides ([c43mpy] [NTf2]) has been used as an electrolyte. A special method for the photo electrochemical conversion of solar energy to electrical energy is advance using rose Bengal, oxalic acid, and ([c43mpy] [NTf2]). 670.0 mV and 61.2 A were the photo potential and photocurrent, respectively. The cell's power was 8.06 W at the power point. The low electrical output levels could be assign to the mobile nature of cation and collection. Common theories have been proposed to explain the ionic liquid's composition. With a fill factor of 0.196, the conversion efficiency was 0.077 percent. The Cell had a storage capacity of 109.0 minutes. It looked at the effects of particular parameters on the electrical efficiency of the cell.

**Keywords:** Rose Bengal, ionic liquid, efficiency in conversion, storage space, photocurrent, photo potential

## 1. Introduction

A solar cell's organization and effectiveness are largely determined by its representation and the properties of the photovoltaic materials used, particularly the light absorbers and their properties. Connections to a circuit outside of the house The charge mediator's selection It's also possible that being involved is vital. Light can be visualized as a stream of photons, definite-size energy packages, or quantum's of electromagnetic wave energy, the energy of which is dependent on the frequency or colour. Photons are created whenever light is absorbed by matter. Electrons are

energized to higher energy levels when they transmit their energy. Followed by a return to their original state. The proximate depletion of fossil fuels and environmental damage are forcing western culture to turn to alternative energy sources. The most abundant energy resources on the planet's surface are sunlight and water, On Earth, the sun shines with a massive coverage that is sufficient to supply the world's electrical condition. Solar energy is a non-traditional renewable energy source that is cheap, clean, plentiful, and immediately available for power generation. Photons from the sun are employed as the driving force in photonic processes, which convert solar energy.Photogalvanic cell (PG) technique, provides a committed and Dilution is an unusual solar power generation and storage process. Sensitized solar power and storage are the result of a dye-charge solution. When these solar cells are charged and discharged, there is no chemical loss. Other [1-3] cells, such as galvanic or voltaic cells, are completely clear from these cells. Various PG cells containing various-dyes, reducing agents, and micelles were studied to improve their electrical efficiency [4-7]. PG was first interested in employing a Pt electrode coated with $Fe^{2+}$ as a reduction agent. now, researchers are working with Pt, calomel electrodes, and dyes such blue toluidine [8, 9] and blue methylene [10]. Mixed dyes such as Azur-B and Methylene B[11], Aethioninee and Azure-B [12], Fluoresce in [13], Azure-A[14], Bengal Rose [15], and others have been make use of in the literature. Mannitol [16], oxalic acid [17], and other reductants Surfactants [18, 19], Tween-80 [5], and sodium lauryl sulphate (NaLS) Ionic liquids (ILs), which are molten salts with melting temperatures at or lower then ambient temperature, show a number of unique properties, including significant electrochemical properties, as well as strong ionic conductivity, non-volatility, and non-flammability [20, 21]. ILs has shown potential for usage as healthy electrolytes in high-energy lithium battery systems due to their features [22-25]. The ILs can be split into two classes based on their electrochemical stability. Tetra alkyl ammonium, pyrrolidinium, piperidinium, and quaternary phosphonium are among the first group of compounds with higher electrochemical stability [26-28]. As an example ([c43mpy][NTf2]). The second category contains imidazolium and guanidinium ILs, which have Narro-wer electrochemical windows and stronger cathodic limiting capacity than the first. Because IL cations have greater diffusion coefficients than anions, the conductivity of an ionic liquid is mostly determined by the mobility of its cation. Liquids based on ionic imidazolium and pyridinum cation Highest ionic conductivity (1 and 10–1 S / m, respectively) [29]. The goal of our research was to look into the electrochemical conversion of solar energy to electrical energy and storage utilizing photo galvanic cells, as well as the factors that affect electrical performance.

## 2. Experimental

### 2.1 Materials Figure 1

Displays the construction of the ionic liquid (IL) make use of in this investigation ([c43mpy] [NTf2]). The ionic liquid (IL), rose Bengal, and oxalic acid were all obtain from Sigma-Aldrich. Merck had manage NaOH (sodium hydroxide) to the patients.

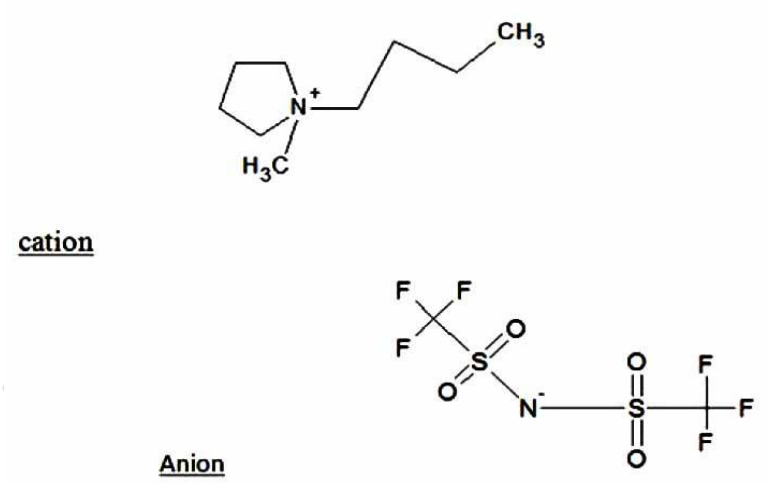


***Figure 1.*** *Structures of cation and anion of the ionic liquid used.*

### 2.2. Setup

PG cell consists of H- shape tube filled with known volume and Photosensitized dye concentration, oxalic acid, ionic liquid ([$c_4$3mpy] [$NTf_2$]) and NaOH. Maximum combine volume was 25.0 ml. homogeneous countries The (Pt) platinum electrode was dipped into the light up branch from 0.25-1.0 $cm^2$ while the calomel electrode was immersed in the other dark branch.

The electrode terminals were attached to two Voltmeters, and the entire cell was discover in the dark. Using simulated visible light source, the branch containing platinum electrode was illuminated. To prevent any thermal impact on the container, the lamp was put in a silica tube filled with a water jacket.

What does this signify in terms of the voltage and current generated? Is mostly likely to the sun's light. A water jacket is employed to prevent the lamp from heating up, resulting in voltage and current generated only by photo-irradiation. After cell illumination, specific parameters such as maximum potential (Vmax), open-circuit potential (Voc), maximum current (imax), and short-circuit current (isc) could be determined. From the examination of the I – V curve, critical parameters of the cell as power at the power point; Ppp, Power point current, Power point ipp potential, Vpp. eq. could be used to calculate the fill factor (FF).

(1) And the total efficiency of energy converse-on could be measured using Eq. (2). Cell efficiency is investigated in terms of half-life (t0.5) time.

$$Fill\ factor\ (FF) = V_{pp} \times i_{pp} / V_{oc} \times i_{sc}$$

change Efficiency % = [Vpp × ipp / Is× Electrode area] × 100

Where, $I_S$ is the intensity of the incident light (mW/cm$^2$).

## 3. Results and Discussion

### 3.1 Various factors influencing the power output

RB Concentration

Table 1 demonstrates the photosensitize- effect on the cell's electrical output. The findings show that the optimal RB concentration with the maximum electrical output is 10.1x10-5M. Dyeing is followed by a decrease in cell electrical production.

Despite this, at low RB dye concentrations, the Pt electrode only receives a minimum number of electrons. As a result, the external circuit has a low current draw. At a higher level because the concentrations of Flash and RB dye are less similarly, the presence of varied m oxidized forms of RB dye may result in a reduction in cell formation (Ab normally has three negative charges). Because RB. Is mono-negative, it degrades more slowly than RB.) Excess quitethan electron loss may lower the RB dye in a Platinum electrode. The dye molecules that exist near Pt and absorb photons have a higher probability of donating electrons to the Pt electrode, which could result in an electrochemical reversible dyeing process [30].

| [Rose bengal] × $10^{-5}$ M | Photopotential (mV) | Photocurrent (µA) | Power (µW) |
|---|---|---|---|
| 10.75 | 453 | 39.2 | 17.75 |
| 10.47 | 560 | 42.3 | 23.68 |
| 10.35 | 632 | 56.5 | 35.70 |
| 10.10 | 670 | 61.3 | 41.00 |
| 9.84 | 601 | 52.6 | 31.61 |
| 9.52 | 514 | 46.5 | 23.90 |
| 9.00 | 475 | 41.3 | 19.61 |
| 7.80 | 429 | 38.5 | 16.51 |

## Concentration of an oxalic acid

**Table 2** shows

The effect of reductant concentration on the cell's photopotential and photocurrent. The maximum electric output concentration was 1.9x10-3M, which was an appropriate concentration. The electrical output and hence the cell characteristics diminish as the concentration falls below or rises above the optimal concentration, as seen in this table. It's possible that the loss of cell power is this is due to the presence of electron scavengers such as oxalic acid and oxalate ion, which are formed when oxalic acid is hydrolyzed. Some fragments may be present as a result of the photo degradation of oxalic acid that may occur as a result of the irradiation. These fragments may reduce the amount of powergenerated.

| [Oxalic acid] × $10^{-3}$ M | Photopotential (mV) | Photocurrent (µA) | Power (µW) |
|---|---|---|---|
| 1.3 | 505 | 47.6 | 24.03 |
| 1.5 | 560 | 51.8 | 29.01 |
| 1.7 | 611 | 56.2 | 34.33 |
| 1.9 | 670 | 61.2 | 41.00 |
| 2.1 | 581 | 55.6 | 32.30 |
| 2.5 | 525 | 49.8 | 26.15 |

### ($[\mathbf{c_4 3mpy}]\ [\mathbf{NTf_2}]$) Concentration

The cell's electrical output has been observed to increase With the IL concentration rising to a high Value. Rise of the photopotential concentrations, Photocurrent, and decreased power.

The findings are published in Table 3-

| ($[c_4 3mpy]\ [NTf_2]$) × $10^{-3}$ M | Photopotential (mV) | Photocurrent (µA) | Power (µW) |
|---|---|---|---|
| 1.0 | 520.0 | 49.50 | 25.74 |
| 2.0 | 561.0 | 52.70 | 29.56 |
| 3.0 | 670.0 | 61.20 | 41.00 |
| 4.8 | 535.0 | 51.50 | 27.55 |
| 5.5 | 490.0 | 45.40 | 22.24 |
| 30.0 | 363.8 | 30.50 | 11.09 |

The classical electrolyte solutions are report in the The smartphone charger has to

Do with its diffusion coefficient D by Equation Nernst – Einstein equation;

$$\Lambda = \frac{z^2 e0FD}{k_B T} = \frac{z^2 NAe_0^2 D}{k_B T}$$

where z, signifies the charge carrier's valence, e0 the elementary charge,($NA$) the Avogadro number, kB the Boltzmann constant, and F the Faraday constant, kB the Boltzmann constant, and F the Faraday constant

1. Anions have a larger degree of intermolecular clustering, resulting in poorer mobility, because cation diffusion is greater than anion diffusion.

2. Recommend anion interaction with an ionic material's Five Cation ring.

3. Cation-anion aggregation in homonuclear and heteronuclear systems;

Applications we can conclude from these observations that as the concentration of IL rises to a certain point, low mobility and viscosity increase, lowering ion mobility and, as a result, lowering electrical generation.

## Change in PH ;

The influence of pH transition on the cell is seen in Table 4. The pH was altered depending on the machine that was making use of. It was achieved by adjusting the pH scale from 12.98 - 13.89 in our course of study. The findings demonstrate that photo galvanic efficiency is affected by the pH of the machine. The photo galvanic cells' electric power output was increased at pH 13.4, while their electrical generation decreased.

In Table 4, pH 13.4 could be found to be lower or higher. The cell's electric output is dwindling. It's possible that the Rationale is due to protonation for RB Coloring. The number of electrons falls because there is an excess of 13.4 at very high pH, OH reachable in a device that can function as an electron scavenger, and therefore the number of electrons reduces. It collided with Pole's electrode. The hydroxyl radical's growth. The RB benzene ring, as well as the RB dye structure, could be targeted.

*Table 4. Effect of different pH on the electrical output.*

| pH | Photopotential (mV) | Photocurrent (µA) | Power (µW) |
|---|---|---|---|
| 13.89 | 372.6 | 30.0 | 11.170 |
| 13.74 | 402.0 | 35.2 | 14.150 |
| 13.62 | 561.0 | 47.5 | 26.64 |
| 13.52 | 623.0 | 52.4 | 32.64 |
| 13.40 | 670.0 | 61.2 | 41.00 |
| 13.26 | 556.0 | 45.6 | 25.35 |
| 13.11 | 442.0 | 33.5 | 14.81 |
| 12.98 | 418.0 | 29.5 | 12.33 |

*Table 5. The performance of photogalvanic cell.*

| Parameters | Observed results |
|---|---|
| Open circuit potential ($V_{oC}$) | 850 mv |
| Short circuit current ($i_{sc}$) | 75.2 µA |
| Maximum photocurrent ($i_{max}$) | 80 µA |
| Time of illumination | 32 min |
| Storage capacity ($t_{1/2}$) | 109 min |
| Conversion efficiency | 0.077% |
| Fill factor | 0.196 |
| Current at power point ($i_{pp}$) | 29.7 µA |
| Potential at power point ($V_{pp}$) | 271.7 mV |
| Power at power point (PP) | 8.06 µW |
| Maximum power | 41.00 µW |

## Diffusion length;

**Figure 3** demonstrates the diffusion-length effect on the Photo induced potential, power and photo induced current. The Diffusion duration was analyzed using differed ntiated cells Lengths between the two electrodes; 2, 3, 6 and 8 cm. It used to be Noted an improve ment of the photopotential, Photocurrent, and therefore the cell 's strength as the Raise the duratio n of the diffusion.We will note the Photopotential rises with diffusion .

The Photocurrent raise and diffusion-length strength Is not quite as high as the photo potential. It confirms it that the recycling reaction of the rate determining steps Semi- or leuco coloring and the oxidized product Reducer in dark chamber [31].

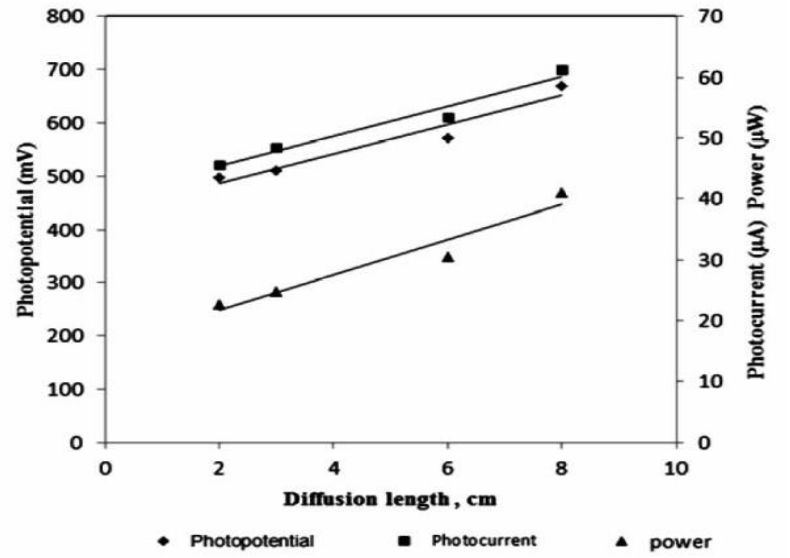


***Figure 3.*** *Effect of variation of diffusion length of the cell on the electrical output.*

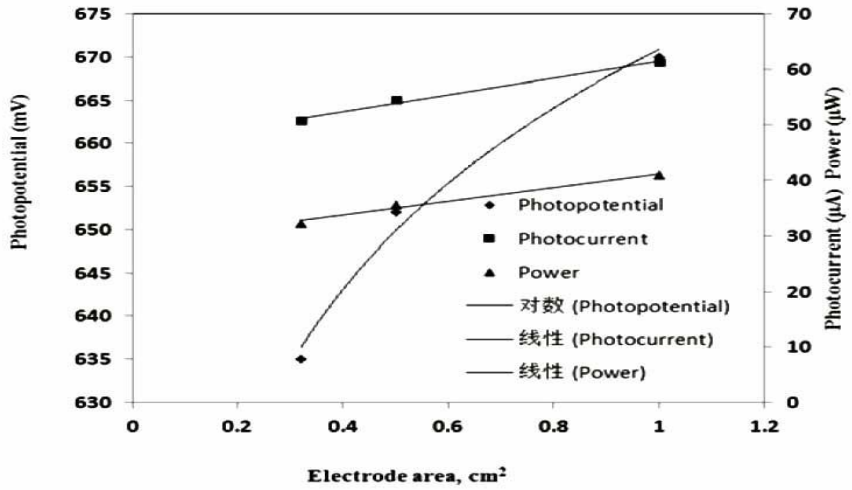


***Figure 4.*** *Effect of variation of electrode area of the cell.*

Electrode Area Figure 4 shows the effect of the Pt Electrode area variation On Photogalvanic cell electrical efficiency.This survey Wasrendered using various types of electrodes 0.3-1 $cm^2$ The results reinforced this with a rise in Electrode field, increased cell electrical production. As the electrode the photocurrent and the power increase linearly Expand field. Logari thmically the photopotential rises. This indicates the photopotential needs to hit Balance importan ce as the area of the electro-des increases. The increase in photocurrent and strength, on the other hand, is proportional to the electrode field. Diffusion transports the dye molecules towards the charged illuminated electrode, resulting in the formation of a static layer near the electrode surface. The increase in photocurrent and strength, on the other hand, is proportional to the electrode field. Diffusion transports the dye molecules towards the charged illuminated electrode, resulting in the formation of a static layer near the electrode surface. The Complex load transfer creation between dye and IL Can be formed on the surface of the electrode which could be a Form of transfer charge with increased donor capacity [32]

# 3.2. data Analysis ;

The current – voltage ( i-V) characteristics of

1. Rose Bengal — Photo-galvanic cell containing oxalic acid (Figure; 5) depicts the device ([c43mpy] [NTf2]). The following parameters can be recover (currently) from I:$I_{SC}$ (Short-circuit current): the cell current approximate at Potential Zero put in.

2. Voc (Open-circuit voltage): the voltage constant in an open circuit. That cell is active when the current is zero.

3. MPP (Maximum Power Point): the point at which the considerable amount of power is produce.

4. Fill factor (FF): the ratio of maximum capacity to maximum capacity. The chain's values should be fast and open.

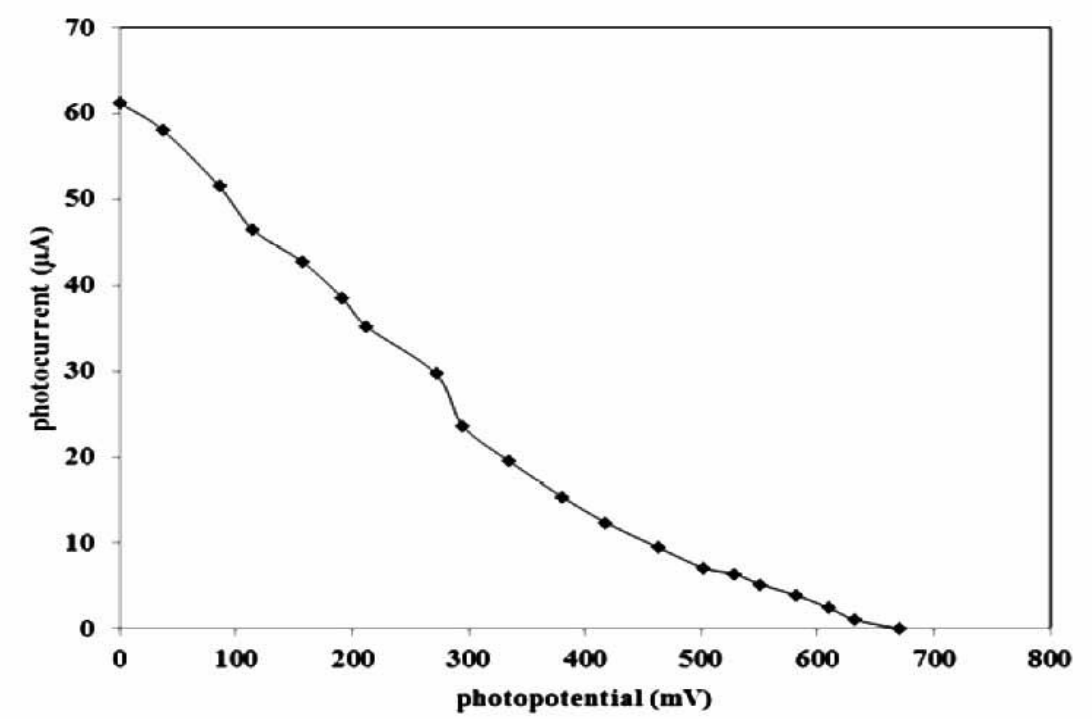


***Figure 5.*** *Current-voltage curve of the cell.*

The cell's storage capacity was calculated in form of T1/2, i.e., the time needed for the electrical output (power) to fall In the absence of light to its half-value at the powerlevel.
The cell will be used in the dark for 109.0 minutes following illumination 32.0 min.

**Figure 6** ; shows how it is handled Photogalvanic Cell Capability. The conversion-efficiency of the Rose system Bengal is measured as a photo sensitizer using. The electric Power point output and incident radiation force. The photogalvanic cell's conversion efficiency is Determined by the following formula as 0.077 per cent: Efficiency of Conversion = [(Vppx ipp)/ (Is x Electrode area) x 100 per cent cm2)]

The total production of the Rose Bengal – Oxalic acid The system ([c4$_3$mpy][NTf$_2$]) is listed in **Table 3.**

This can be due to the covalent nature of Ionic liquid cannot effectively permit a charge to pass. The formal charges or the effects of electro negativity within the Compounds produce dipoles that allow for a certain charge (although A little) stabilizable and transportable. So they are Arebad ele ctricity conductors but have good capacity Effectiveness. We can infer from those findings that, the order of Production of electricity is to: Non-ionic surfactant > cationic liquid with ionic covalence .

The surfactants increase operation of the cells by I Overcoming the electron transfer back, (ii) Electron increase Switch to Photosensitizer and (iii) Solubility Improvement [34] Sensitizer molecules stability[35].

It also happens Noted that the ionic liquid network Photogalvanic cell Has room for conversion and storage, 0.077 percent and Whereas 109.0 min. These are comparatively higher in Comparison with framework previously published [8]containing Green-arabinose malachite NaLS (0.059%, 32.0 min),It also noted that photogalvanic cells previously recorded [5, 35] have relatively lower storage capacity with surfactants EDTA – thionine – azur B (59.0) as opposed to our system; Min), EDTA – safranine – Entre 80 (20.0 min), EDTA – Safranin – O-DSS (80.0 min), blue – xylose – NaLS- methylene Systems 55.0 min.4

# Conclusions;

Conversion of solar energy into electricity by photo-electroPhotogalvanic cell energy and storage finds a very signify-cant Simple power generating technique. Our Information Analysis The analysis shows a 0.077 percent conversion efficiency and Storage space using 1-Butyl-3-was 109.0 min. Imide metylPyrrolidiniumbis (trifluoromethhlsulfonyl) as This system includes electrolyte.Various factors which affect the Cell electrical output as; concentration of a photosensitizer, Alteration of pH, decreased concentration, duration of diffusion and Electrode field has been researched. The analysis proved the order For the generation of electricity: non-ionic surfactant > cationic > The ionic liquid is covalent. The cell should, because there is no external circuit Keep light energy in stock

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