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Photogalvanic Effect in Mixture of Dyes and Reductant System

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Photogalvanic effect was observed for system containing mannitol and nitrilotriacetic acid (NTA) as reductant with azure A, azure B and azure C as a mixture of photosensitizers. The photocurrent and photopotential generated by azure A, azure B, azure C and NTA system were 80 μA and 409 mV respectively. Effect of variables on electrical output, fill factor, conversion efficiency and performance of the cell in dark has been studied.

INTRODUCTION

The literature survey reveal that different photo-sensitizers like proflavin[1], methylene blue[2], azure dye[3, 4] etc. and micelles[5] have been used in photogalvanic cell, but less work has been done using mixture of dyes with reductant in this system.

EXPERIMENTAL

Azure A (Chroma), Azure B (Chroma), Azure C (Koch-Light), mannitol (Eastman), NTA (Koch-Light) and sodium bydroxide (Hi-Media) were used in this work. A mixture of solution of mannitol or NTA and dyes in alkaline medium was taken in H-type cell. A platinum electrode was dipped in one arm of the H-type cell and was exposed to 200 W tungsten lamp (Sylvania). Other limb centaining saturated calomel electrode (SCE) was kept in dark. A water filter was used for cutting thermal radiation.

The photochemical bleaching of dyes with reductant was studied potentiometrically using digital multimeter (Systronics Model 435) and microammeter (Kew). The i-V charateristic of the cell was observed using on external (log 500 K).

RESULTS AND DISCUSSION

The optimum conditions for dye-mannitol and dye-NTA system determined first are reported in Table 1

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TABLE 1
[DYES], [REDUCTANT], pH AND ELECTRICAL OUTPUT OF THE CELL
Intensity 10.4 mW cm^{-2} Temperature = 303 K

System	[Dye] × 10^5M	[Red] × 10^3M	pH	Photopotential mV	Photo current μA
Azure A–mannitol	8.0	2.0	11.2	655.0	30.0
Azure B–mannitol	9.6	2.0	11.7	321.0	35.0
Azure C–mannitol	20.0	2.0	11.5	331.0	40.0
Azure A–NTA	2.4	20.0	11.3	362.0	60.0
Azure B–NTA	8.0	20.0	11.1	340.0	60.0
Azure C–NTA	20.0	20.0	11.3	347.0	70.0

The optimum conditions for dyes and reductants for reductant and mixture of dyes system are reported in Table 2

TABLE 2
[DYES], [REDUCTANT], pH AND ELECTRICAL OUTPUT AT OPTIMUM CONDITION.

System	[Azure A] × 10^5 M	[Azure B] × 10^5 M	[Azure C] × 10^4 M	[Reductant] × 10^2 M	pH	Photo-potential mV	Photo-current μA
Azure A–Azure B–Azure C–NTA	4.8	5.2	1.2	1.8	11.4	409.0	80.0
Azure A–Azure B–Azure C–Mannitol	4.8	5.6	0.8	0.22	11.8	395.0	70.0

Current-Voltage (i-V) Characteristics, Conversion efficiencies, Fill-Factor and Performance of the Cell

The open circuit voltage (V_{oc}) and short circuit current (i_{sc}) of the photogalvanic cell were measured using digital multimeter (keeping the circuit open) and microammeter (keeping the circuit closed) respectively. The potential and current values in between two extreme values (V_{oc} and i_{sc}) were recorded with the help of carbon-pot (log 500 K) in circuit, through which an external load was applied. The current-voltage data are given in Tables 3 and 4.

TABLE 3
i-V CURVE OF AZURE A–AZURE B–AZURE C–NTA SYSTEM
pH = 11.4, Intensity = 10.4 mW cm^{-5}, Temp. 303 K
[Azure A] = 4.8×10^{-5} M, [Azure B] = 5.2×10^{-5} M,
[Azure C] = 1.2×10^{-4} M, [NTA] = 1.8×10^{-2} M

*Potental (mV)	Photo-current (μA)	Fill Factor (n)
1088.0	0.0	
1039.0	10.0	
985.0	20.0	
840.0	30.0	
592.0	40.0	0.28
378.0	50.0	
250.0	60.0	
27.0	70.0	
0.0	80.0	

*Absolute value.

TABLE 4
i-V CURVE OF AZURE A–AZURE B–AZURE C–MANNITOL SYSTEM
(pH=11.8) Intensity = 10.4 mW cm^{-2}, Temperature = 303 K
[Azure A] = 4.8×10^{-5} M, [Azure B] = 5.6×10^{-5} M,
[Azure C] = 0.8×10^{-4} M, [Manitol] = 2.2×110^{-3}M.

*Potential (mV)	Photo-current (μA)	Fill factor (n)
1105.0	0.0	
1050.0	10.0	
1020.0	20.0	
895.0	40.0	
610.0	40.0	
289.0	50.0	0.31
152.0	60.0	
0.0	70.0	

*Absolute value.

It was observed that i-V curve deviated from its regular rectangular shape. A point was determined within the curve, where the product of current and potential is maximum. This point is called power point (PP). The values of photocurrent and potential at power point are represented as i_{pp} and V_{pp} respectively. The fill-factor and conversion efficiency of the cell were determined using the formula

$$\text{Fill factor} = \frac{V_{pp} \times i_{pp}}{V_{oc} \times i_{sc}}$$

$$\text{Conversion efficiency} = \frac{V_{pp} \times i_{pp}}{10.4\ \text{mW}}\ \text{cm}^{-2} \times 100\%$$

The performance of the cell was measured by applying the external load necessary to have potential and current at power point after removing the source of light. The fill factor, conversion efficiency and performance of the cell are given in Table 5.

TABLE 5
FILL-FACTOR, CONVERSION EFFICIENCY AND PERFORMANCE OF THE CELL.
Intensity=10.4 mW cm^{-2} Temperature=303 K

System	Fill-factor	Conversion efficiency (%)	Performance (Capacity to work in dark) min
Azure A–Mannitol	0.25	0.08	20.0
Azure B–Mannitol	0.37	0.13	30.0
Azure C–Mannitol	0.26	0.11	78.0
Azure A–NTA	0.27	0.17	67.0
Azure B–NTA	0.29	0.18	48.0
Azure C–NTA	0.26	0.19	38.0
Azure A–Azure B–azure C–NTA	0.28	0.24	86.0
Azure A–Azure B–Azure C–Mannitol	0.31	0.23	99.0

Effect of Mixture of Dyes

Each dye absorbs some part of light and gives peak. When two or more dyes were used simultanously an enhancement of amplitude was observed in resultant peak. This behaviour is shown in Fig. 1.

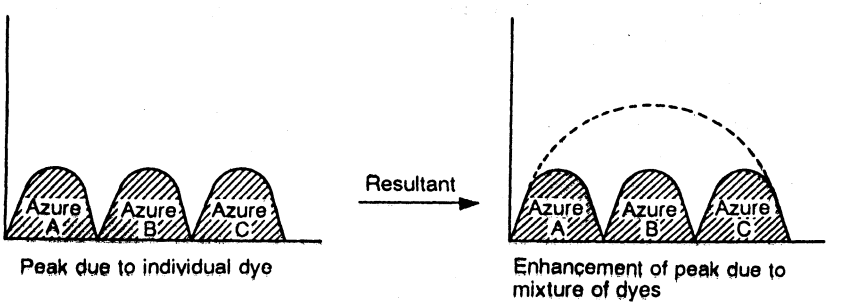

Fig. 1 Effect of mixture of dye.

It was observed the electrical output, conversion efficiency and performance of the cell increased if more than one dye were used with reductant. The rise in the results observed due to additive absorption of light by all dyes.

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N.R. DHAR MEMORIAL GOLD MEDAL AWARD

DR. S.P. SINGH, Professor in the Post-Graduate Department of Chemistry, Gaya College, Gaya (Bihar), India, has been awarded N.R. Dhar Memorial Gold Medal for his contribution to organic chemistry. The award was given to Dr. Singh at the recently held Silver Jubilee celebration of Indian Society of Agricultural Chemistry at Allahabad. The University Vice Chancellor Prof. R.C. Mehrotra presented the medal to Dr. Singh.

The award has been named after the great Indian chemist, Prof. Neel Ratana Dhar, who is regarded as the father of physical chemistry in the country. Dr. Singh, a product of Allahabad University, has successfully guided several research projects in the field of chemistry.