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Dye-sensitized solar cells using some organic dyes as photosensitizers: A new and efficient tool for quantitative analysis

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Abstract

In this research, a novel approach was developed for the quantitative analysis of chemical compounds using dye-sensitized solar cells (DSSCs). The analyte under investigation was used as the sensitizing dye in the DSSC, which then functioned as a detector to quantify the target substance. The sample solution was exposed to the full spectral output of a tungsten lamp, and the DSSC acted as a detector by measuring the intensity of absorbed light. This system is conceptually similar to a conventional UV-Vis spectrophotometer, but it operates without a monochromator, making it a simpler and more cost-effective alternative. Four types of DSSCs were created using different dyes: N719, Bromoethylene Blue, Quinalizarin, and 2,7-Dichlorofluorescein. These solar cells replaced the traditional photodetector in a UV-Vis spectrophotometer to study the absorption of tungsten lamp light by solutions containing either the same dye as that used in the DSSC or different dyes. Experimental observations showed that when the solution contained the same dye as the DSSC (matched dye), the absorption response was logarithmically proportional to the analyte concentration. In contrast, when the solution contained a different dye (mismatched dye), the system followed the Beer–Lambert law, demonstrating a linear relationship between absorbance and concentration. This technique has potential for both qualitative and quantitative detection of analytes. For analytical applications, a specially fabricated DSSC incorporating the dye of interest acts as a dedicated detector for each specific analyte

Keywords
Dye-sensitized solar cell (DSSC) ; Quantitative detection; Detector; UV-Vis spectrophotometer, different dyes.

1. INTRODUCTION

The ever-growing population requires the consumption of energy in various forms, so researchers focus on gathering energy from various sources[1]. Nonrenewable energy sources such as carbon-based fossil fuels (coal, petroleum, and natural gas) are running out, aside from their environmental disadvantages, and cannot be replaced in our lifetime. Therefore, scientists typically focus on renewable energy-based energy conversion devices. Solar, wind, hydroelectric, biomass, and geothermal are some examples of renewable energy resources available on Earth [2]. In the case of solar energy, radiation from sunlight can produce heat and light, cause photochemical reactions, and lead to the production of electricity [3].The conversion of light energy to electrical energy is achieved by devices called photovoltaic cells. The photovoltaic effect occurs when a semiconductor material absorbs light and generates an electrical voltage. Since electricity is a fundamental need for mankind, this impressive energy source can be used to convert solar energy into electrical energy using solar cell technology. The first solar cells used silicon crystals to achieve this effect.

First-generation photovoltaic cells are based on monocrystalline or polycrystalline silicon wafers. These cells exhibit high efficiency and long-term stability, making them dominant in the photovoltaic market especially in environments with high solar irradiance due to their mature fabrication processes and proven performance. Second-generation photovoltaic cells utilize thin-film technologies, employing materials such as amorphous silicon (a-Si), cadmium telluride (CdTe), and copper indium gallium selenide (CIGS). These materials are deposited on low-cost substrates like glass, steel, or flexible plastics, enabling low-cost production and the fabrication of lightweight and flexible solar panels. Although second-generation cells generally exhibit lower efficiencies compared to their first-generation counterparts, they offer notable performance under low-light conditions and are particularly well-suited for building-integrated photovoltaics (BIPV) applications [4-6]. Third-generation photovoltaic technologies represent emerging innovations, such as dye-sensitized solar cells (DSSC). DSSCs are distinguished by their low production cost, high efficiency under diffuse and scattered light, and ability to generate electricity at

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non-optimal illumination angles. Additionally, their flexibility and transparency open pathways for novel applications, including integration into windows, wearable electronics, and portable devices [4]. These unique properties of third-generation DSSCs not only make them attractive for renewable energy systems but also render them effective as optical detectors in various analytical applications, particularly where light sensitivity and adaptability are essential.

Dye-sensitized solar cells (DSSCs) are a prominent category of third-generation photovoltaic technologies, known for their unique photoelectrochemical mechanism. A typical DSSC consists of the following key components:

(1) Transparent Conductive Oxide (TCO) Electrode: This layer serves as a transparent conductive electrode and the entry point for incident light. It is usually made of fluorine-doped tin oxide (FTO) or indium tin oxide (ITO) and is deposited on glass or plastic substrates.

(2)Photosensitizing Layer (Dye Molecules): This layer contains a light-sensitive dye, such as ruthenium complexes, organic dyes, or natural pigments, which absorbs light and generates photoexcited electrons.

(3) Electrolyte Layer: This layer typically consists of a redox couple, such as iodide/triiodide (I^{-}/I_3^{-}). The electrolyte regenerates oxidized dye molecules by transferring electrons from the counter electrode back to the dye, sustaining the electron flow in the photoelectrochemical cycle.

(4) Counter Electrode (Cathode): This electrode, often made of platinum or other catalytic materials, facilitates the reduction of the electrolyte, allowing electrons to return to the system and completing the electrical circuit.

These integrated components enable DSSCs to operate effectively under a wide range of lighting conditions, with low production costs, high efficiency in diffuse light, and mechanical flexibility, making them suitable not only for renewable energy harvesting but also for analytical detection systems for photoexcited electrons [7,13] .

Upon absorption of light, the dye molecules become photoexcited and inject their electrons into the conduction band of TiO_2 (Figure 1). These electrons then travel through the semiconductor network and are later captured by the transparent conductive oxide (TCO) electrode. From there, they are sent to the external circuit, generating an electric current. Simultaneously, the electrolyte replenishes the oxidized dye molecules, ensuring a continuous flow of electrons within the cell and allowing for uninterrupted operation [8,12] .

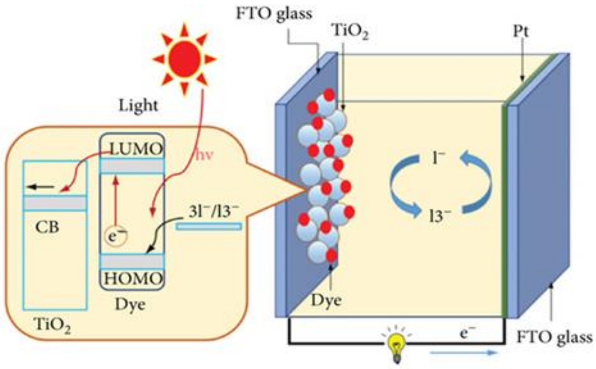

Fig. 1. General structure of a dye-sensitized solar cell [9]

An ideal dye for use in dye-sensitized solar cells (DSSCs) should have a broad and intense absorption spectrum that covers the visible (Vis) and near-infrared (NIR) regions. Extending the absorption range into the ultraviolet-visible (UV-Vis) domain is also beneficial. These spectral characteristics improve photocurrent generation by allowing the utilization of a wider portion of the solar spectrum, leading to higher overall light-harvesting efficiency [10,14] .

For long-term operational stability, the dye should either possess intrinsic hydrophobicity or be chemically modified to resist water infiltration. A hydrophobic environment not only decreases the risk of dye detachment from the semiconductor surface but also helps prevent oxidative photodegradation, which is crucial for maintaining device efficiency over extended periods [11,15,16] .

Furthermore, the dye molecule should incorporate anchoring groups such as carboxylic acid, phosphonate, or hydroxamate moieties. These functional groups promote strong chemical binding to the TiO_2 surface, ensuring robust interfacial adhesion and efficient electronic coupling for rapid charge transfer [17-19].

In this study, a dye-sensitized solar cell (DSSC) was used as a photovoltaic transducer for quantitative analysis, utilizing the same dye found in the analyte solution. The device's photoelectrochemical output was systematically compared to the analyte concentration, allowing for sensitive and reproducible quantification.

This dual-purpose method showcases the functional versatility of DSSCs in solar energy conversion and analytical chemistry. It also introduces a novel, cost-effective, and instrument-free strategy for determining concentration based on the cell's photovoltaic performance.

The primary objective of this study is to develop an innovative approach for the qualitative and quantitative analysis of dye compounds using dye-sensitized solar cells (DSSCs) as optical detectors. In this investigation, the DSSC is utilized not only as a photovoltaic energy converter but also as a functional optical sensing platform capable of recording photonic responses from dye-containing solutions. This dual-function system enables the analysis of optical absorption characteristics without relying on conventional spectroscopic components such as monochromators. The methodological framework is based on the utilization of various dye molecules as sensitizers in the fabrication of DSSCs, allowing precise optical signal quantification through their spectral responses. This approach is expected to provide a simplified, low-cost, and portable alternative for dye detection in analytical chemistry applications.

In recent years, spectrophotometric methodologies have been significantly strengthened through the incorporation of task-specific ionic liquids (TSILs), which provide high selectivity and efficiency for trace analysis of pharmaceuticals and environmentally relevant species. For example, a homogeneous solvent-based microextraction (HSBME) strategy employing a TSIL has been reported for the sensitive spectrophotometric determination of fluoxetine in real water and urine samples, achieving satisfactory enrichment factors and analytical performance [20]. Likewise, a rapid in-situ solvent formation microextraction utilizing a synthesized TSIL was successfully applied to the quantification of U(VI) ions in aqueous matrices, demonstrating high precision and reproducibility [21]. Moreover, the application of pyrrolidinium-based TSILs in the extraction and determination of trace Cr(VI) ions from environmental water samples further illustrates the versatility of ionic liquid-assisted spectrophotometric approaches [22] .

The principal innovation of this research lies in the multifunctional application of dye-sensitized solar cells (DSSCs) as spectral detectors, which eliminates the need for complex optical components like prisms or gratings commonly used in traditional spectrophotometers. Instead, the system operates using a broad-spectrum light source, such as a tungsten lamp, allowing for significant simplification of the device architecture. This design reduces fabrication costs and enables the system to be miniaturized for portable analytical applications. Experimental results indicate that the system demonstrates two distinct optical response behaviors based on the spectral overlap between the analyte dye and the sensitizer dye in the DSSC: an exponential response correlated with the logarithm of concentration when the dyes are spectrally similar, and a linear response with concentration when they differ. This behavior not only increases the sensitivity of the method but also facilitates the development of selective sensors capable of distinguishing between different dye compounds based on their spectral signatures.

2. EXPERIMENTAL

2.1. Materials and methods

All chemicals and materials were used as received, without any further purification.

Titanium dioxide nanoparticles (TiO_2, anatase phase, ≥99.7% purity, ~25 nm average particle size) were obtained from Sigma-Aldrich (St. Louis, MO, USA) and used in the preparation of the photoanode paste.

Polyethylene glycol (PEG, molecular weight = 400, ≥99% purity,) was purchased from Merck (Darmestadt,Germany) and added to the paste formulation at 3% v/v to improve viscosity and film-forming properties.

Nitric acid (HNO_3, 0.65) from Scharlau (Barcelona, Spain) was diluted to 0.1 M and employed in the surface treatment of FTO substrates prior to TiO_2 deposition.

Absolute ethanol (≥99.5%) was supplied by Merck (Germany, Darmstadt) and used to reduce surface tension during paste preparation and coating processes.

Fluorine-doped tin oxide (FTO) glass with a sheet resistance of approximately 7 Ω/sq was sourced from Solar Cell – Sharif (Tehran, Iran). These conductive substrates were used for both the photoelectrode and counter-electrode components.

Dye solutions (including N719 and analogous dyes, ≥98% purity), specifically formulated for DSSC applications, were provided by Solar Cell – Sharif (Tehran, Iran) and used to sensitize the TiO_2 films.

Hydrochloric acid (HCl, 0.37), acquired from Sigma-Aldrich (St. Louis, MO, USA), was diluted to 0.01 M and used for the chemical cleaning of FTO glass substrates.

Potassium iodide (KI, ≥99%) and iodine (I_2, ≥99.8%) were obtained from , respectively, and used in the formulation of the redox electrolyte.

Acetonitrile (CH_3CN, ≥99.9%, HPLC grade) was purchased from Carlo Erba (Piazza,Italy) and employed as the solvent in the electrolyte system due to its favorable volatility and compatibility with the I^-/I_3^- redox couple.

A pre-formulated dye-sensitized solar cell (DSSC) electrolyte solution containing the I^-/I_3^- redox couple was obtained from Solar Cell – Sharif (Tehran, Iran) and used without modification.

Surlyn ionomer resin (≥99% purity), supplied by DuPont (Wilmington ,USA), served as the spacer and sealing material between the electrodes during cell assembly.

Polyethersulfone (PES) membrane filters with a pore size of 0.45 µm, purchased from Sartorius (Göttingen, Germany), were used to remove particulates and impurities from all liquid reagents.

2.2 Apparatus

Several instruments were used throughout the fabrication, treatment, and characterization processes:

An ultrasonic bath (Model: Elma S30H, Elma, Germany) was employed to ensure homogenous dispersion of TiO_2 nanoparticles in the colloidal paste.

A high-temperature annealing furnace (Model: LHT 02/17 LB, Nabertherm, Germany) was used for sintering the TiO_2 films at elevated temperatures, thereby enhancing their crystallinity and adhesion to the substrate.

A pH meter (Model: 827, Metrohm, Switzerland) was utilized for precise pH adjustment of the dye solutions prior to the sensitization of TiO_2 films.

A 100 W tungsten lamp (Philips, Netherlands) served as a visible-light source for preliminary photoresponse testing.

A manual doctor blade coater, custom-fabricated by Payam Noor Engineering Group (Iran), was used to deposit a uniform TiO_2 film onto the conductive side of the FTO glass.

A UV–Vis spectrophotometer (Model: UV-120-02, Shimadzu Corporation, Japan) was employed for optical characterization of dye-sensitized films. The instrument features a dual-light source system—deuterium lamp for the UV region and tungsten lamp for the visible region—and operates within the 190–1100 nm wavelength range. It offers a wavelength accuracy of ±0.3 nm and an absorbance accuracy of ±0.005 A. Its detection limit reaches 0.0001 Abs at 260 nm, with a wavelength stability of ±0.1 nm and a spectral resolution of 1.0 nm. Measurements were performed in transmittance, absorbance, and reflectance modes using a silicon photodiode array detector. The system includes an automatic zero-adjustment feature, LCD display, and internal data storage. Data analysis was conducted using Microsoft Excel software.

2.3 DSSC Fabrication Method

The fabrication process of dye-sensitized solar cells (DSSCs) involves six systematic steps to ensure the preparation of high-quality photoelectrodes, optimal dye adsorption, and efficient cell assembly. The methodology is detailed as follows:

2.3.1 Preparation of TiO_2 Paste

To prepare the TiO_2 paste, 0.7 g of polyethylene glycol (PEG, purity ≥99%, Mw = 400, Sigma-Aldrich, USA) was dissolved in 2 mL of diluted nitric acid with a final concentration of 0.1 M under magnetic stirring. Upon complete dissolution of PEG, 10 g of titanium dioxide nanoparticles (purity ≥99.7%, anatase phase, average particle size ~25 nm, Sigma-Aldrich, USA) were added to the solution. The resulting mixture was stirred for 1 h to form a uniform suspension.

Subsequently, 2 mL of was added to reduce surface tension and facilitate uniform spreading of the paste on the photoelectrode. The mixture was then sonicated for 30 min to ensure homogeneous particle dispersion, followed by an additional 1 h of magnetic stirring to obtain a stable and homogeneous paste suitable for photoelectrode coating [23] .

2.3.2 Dye Preparation

To adjust the pH of the dye solution, an appropriate amount of hydrochloric acid (1 M, Merck) was gradually added dropwise until the pH reached 1. Acidification promotes protonation of functional groups (e.g., carboxyl groups) on the dye molecules, thereby enhancing the interaction between the dye and the TiO_2 surface, leading to more effective dye adsorption [24] .

The dye solution was then filtered through a 0.45 µm syringe filter (PES membrane, Sartorius, Germany) to remove suspended particles and impurities, yielding a high-purity dye solution.

2.3.3 Electrolyte Preparation

Acetonitrile (CH_3CN, ≥99.9%, HPLC grade, Carlo Erba, Italy) was used as the solvent for electrolyte preparation due to its high dielectric constant and low viscosity, which enhance ionic mobility. The redox electrolyte was prepared by dissolving potassium iodide (KI, ≥99%) and iodine (I_2, ≥99.8%) in acetonitrile to form the I^-/I_3^- redox couple, which facilitates electron transfer between the photoelectrode and the counter electrode. The solution was continuously stirred to ensure complete dissolution and homogeneous distribution of the redox species [25] .

2.3.4 Substrate Preparation

FTO glass substrates were cleaned sequentially by sonication in deionized water, acetone, and ethanol (≥99.5%) for 15 min each. After cleaning, the substrates were dried under a nitrogen stream and heated at 100°C to remove residual moisture, thus improving the adhesion of the TiO_2 paste to the substrate surface [26].

2.3.5 Photoelectrode Fabrication

The TiO_2 paste was applied onto the conductive side of the FTO substrate using the doctor blade technique to form a uniform film with an approximate thickness of 10 µm [27] . The coated substrates were subsequently sintered at 450°C for 30 min to crystallize the TiO_2 nanoparticles, thereby enhancing electron mobility. The annealed photoanodes were immersed in the dye solution for 12 to 24 h in the dark to achieve maximum dye adsorption on the TiO_2 surface.

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2.3.6 Solar Cell Assembly

The assembly of the DSSC involved the following components: the photoanode, a platinum-coated FTO counter electrode, electrolyte, thermal sealing film, and a spacer. The photoanode and counter electrode were aligned facing each other, with a spacer made of a thermoplastic polymer such as Surlyn (Ionomer Resin, DuPont), a material typically composed of polyethylene and methacrylic acid, placed between them to maintain a uniform electrolyte layer. This thermoplastic polymer also served to seal the cell and prevent electrolyte leakage (Figure 2).

The electrolyte solution was introduced into the inter-electrode space via capillary action through a pre-drilled hole in the counter electrode. Finally, the device was hermetically sealed using a thermal laminating film to ensure complete encapsulation.

This assembly method ensured structural integrity and reliable operational performance of the DSSCs, while providing a robust platform for evaluating dye concentration through photoelectrochemical measurements [28].

A UV-120-02 spectrophotometer (Shimadzu, Japan) was modified by replacing its original photodetector with the fabricated dye-sensitized solar cell (DSSC) (Figure 3b). The absorbance of dye solutions with various concentrations (0.1 to 1.0 mM) was measured under uniform illumination from a tungsten lamp (Figure 3).

2.4.1 Calibration Procedure

The modified spectrophotometer was calibrated using a standard reference solution to ensure measurement accuracy. The samples were prepared through serial dilution and placed in quartz cuvettes with a 1 cm optical path length. Absorption spectra were recorded in the wavelength range of 400–700 nm at room temperature (25 ± 1 °C).

2.4.2 Background Noise Reduction

A pure solvent sample was used as a reference to reduce background noise. Absorbance data were analyzed using Microsoft Excel software, and calibration curves were plotted to evaluate the linearity and sensitivity of the DSSC as a photoelectrochemical detector for quantitative analysis.

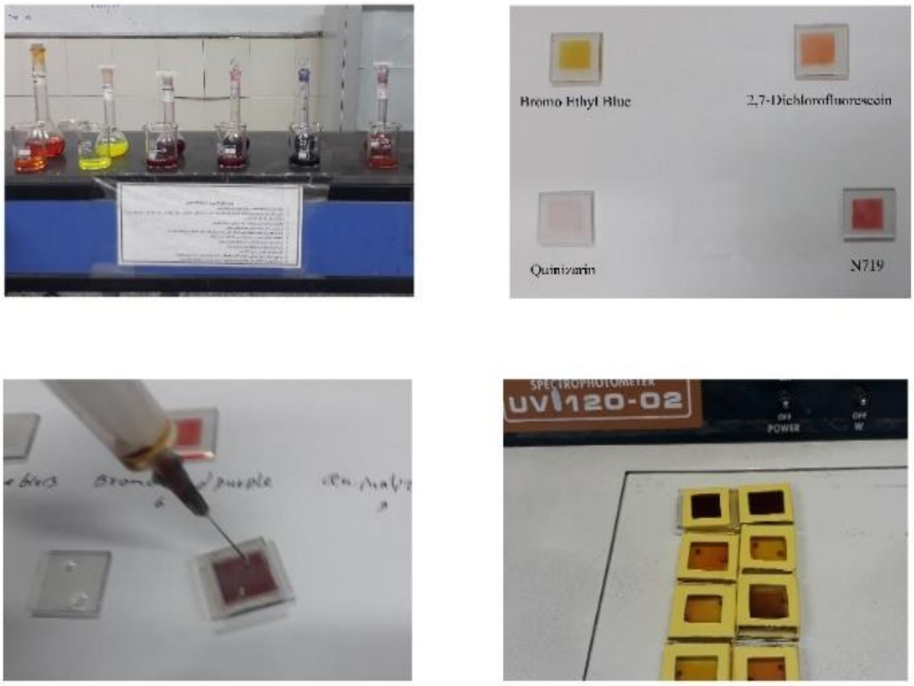

Fig. 2. Complete sealing of the solar cell using thermal lamination

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Fig. 3. (a) Shimadzu UV-120-02 Spectrophotometer (b)Replacement of the original detector with DSSC

2.5. Fabrication and optical characterization of the DSSC

A dye-sensitized solar cell (DSSC) was fabricated using the N719 dye to investigate its photovoltaic performance under various light irradiation conditions. The DSSC was systematically exposed to sodium, mercury, and tungsten light sources to evaluate its photoelectric response. Notably, the highest photovoltage was observed under tungsten light irradiation, indicating a strong spectral overlap between the dye’s absorption characteristics and the emission profile of the tungsten source.

The optical absorption characteristics of the N719 dye (Figure 4) were precisely characterized using a UV-120-02 spectrophotometer (Shimadzu, Japan), providing detailed insights into its light-harvesting efficiency.

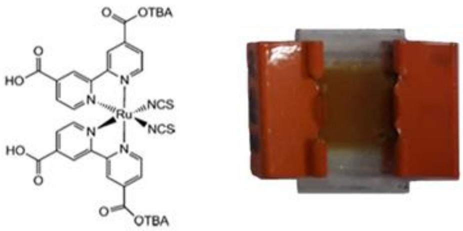

Fig. 4. Industrial Standard Dye N719 (Di-tetrabutylammonium cis-bis(isothiocyanato)bis(2,2′-bipyridyl-4,4′-dicarboxylato) ruthenium (II))

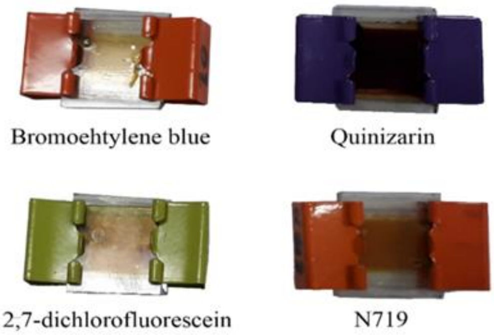

Fig. 5. Fabrication of dye-sensitized solar cells using different dyes

3. Results and discussion

The selected dyes for evaluation included N719, Bromo Ethyl Blue, 2,7-Dichlorofluorescein, and Quinizarin (Figure 5). For each dye, a separate DSSC was fabricated, and its applicability in photochemical sensing was assessed

2.3.1. Absorbance of the selected dyes

Table 1. Absorption of Different Dyes with Matched Detector

Solution Dye	DSSC Detector	Concentration (mM)	Absorbance
Bromo Ethyl Blue	Bromo Ethyl Blue	1.0, 0.5, 0.25, 0.125	0.37, 0.32, 0.25, 0.19
Quinizarin	Quinizarin	1, 0.5, 0.25, 0.125	0.75, 0.61, 0.45, 0.29
2,7-Dichlorofluorescein	2,7-Dichlorofluorescein	1,0.5,0.25,0.125,0.0625,0.03125	2.0,1.85,1.71,1.56,1.38,1.23
N719	N719	1, 0.5, 0.25, 0.125	0.20, 0.15, 0.08, 0.03

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To assess the quantitative analytical performance of the DSSCs, stock dye solutions were prepared at an initial concentration of 1.0 mM and subsequently diluted to concentrations of 0.5 mM, 0.25 mM, and 0.125 mM. The optical absorption of each diluted solution was measured using DSSCs fabricated corresponding photovoltaic response (Figures 6-10). with either the same dye (homologous detection) or different dyes (heterologous detection). The absorption data for each DSSC were recorded using the modified UV-120-02 spectrophotometer (See Tables 1 and 2) and analyzed to establish the relationship between dye concentration and the

Table 2. Absorption of Different Dyes with mismatched Detector

Solution Dye	**DSSC Detector**	**Concentration (mM)**	**Absorbance**
2,7-Dichlorofluorescein	Bromo Ethyl Blue	1, 0.5, 0.25, 0.125	0.71, 0.34, 0.14, 0.06
2,7-Dichlorofluorescein	Quinizarin	1, 0.5, 0.25, 0.125, 0.625	0.515 , 0.501,0.453,0.3770.368
Quinizarin	2,7-Dichlorofluorescein	1, 0.5, 0.25, 0.125	1.91 , 1.29, 0.95 , 0.78, 0.70
2,7-Dichlorofluorescein	N719	1, 0.5, 0.25, 0.125	0.37, 0.29, 0.24, 0.21
Arsenazo III	N719	1, 0.5, 0.25, 0.125	1.04, 0.51, 0.20, 0.08

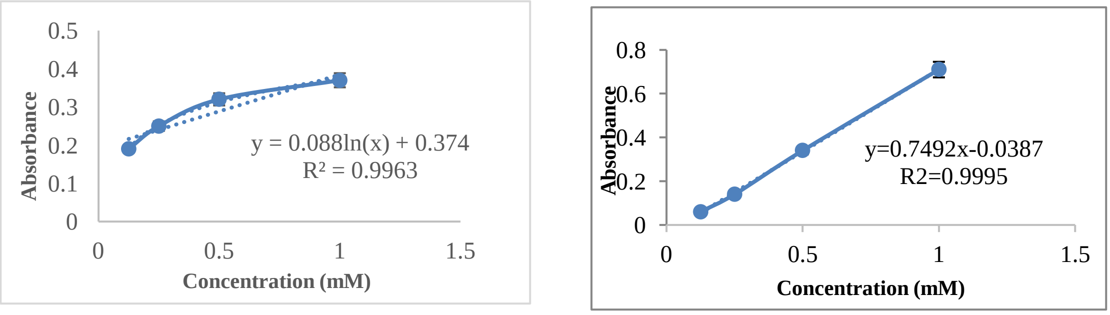
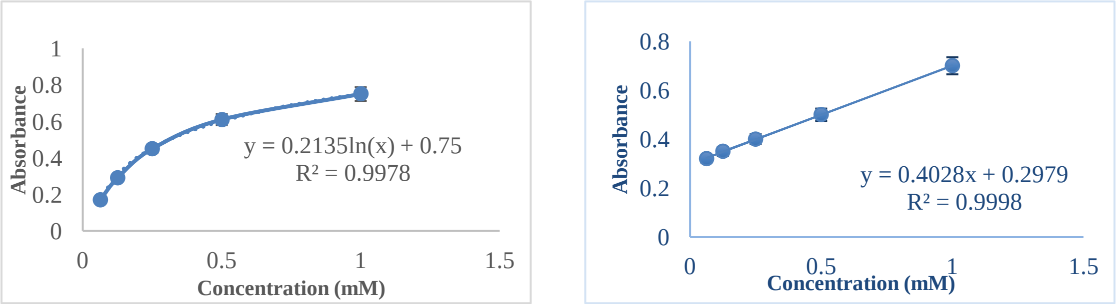


Fig . 6. (a) absorption of bromoehtylene blue dye in the solar cell fabricated with bromoehtylene blue. (b) Absorption of 2,7-dichlorofluorescein solution in the solar cell fabricated with bromoehtylene blue.



(a) (b)

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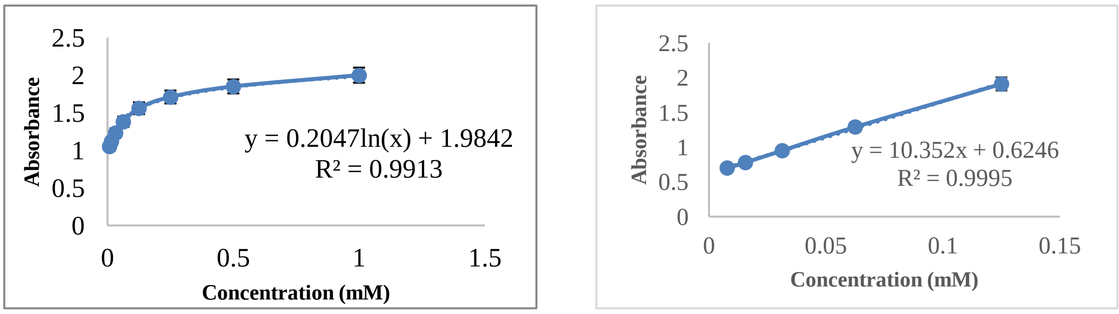
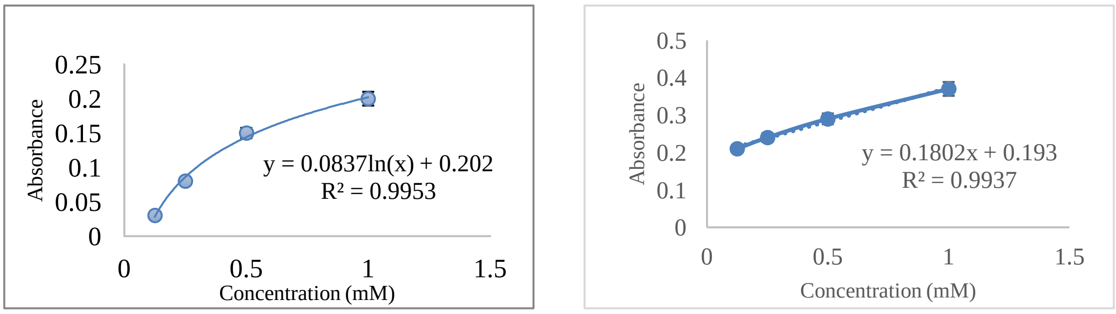
Fig. 7. (a)Absorption of quinizarin solution in the solar cell fabricated with quinizarin. (b) Absorption of 2,7-dichlorofluorescein solution in the solar cell fabricated with quinizarin.



(a) (b)

Fig. 8. (a) Absorption of 2,7-dichlorofluorescein solution in the solar cell fabricated with 2,7-dichlorofluorescein.(b) Absorption of kinalizarin solution in the solar cell fabricated with 2,7-dichlorofluorescein.



(a) (b)

Fig. 9. (a) Absorption of N719 solution at different concentrations in the solar cell fabricated with N719 as the detector.(b) Absorption of 2,7-dichlorofluorescein solution in the solar cell fabricated with N719 as the detector.

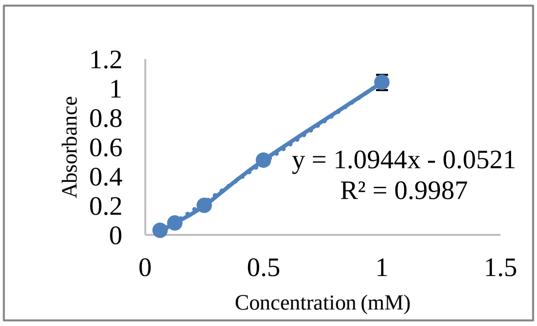


Fig. 10. Absorption of Arsenazo III solution at different concentrations in the solar cell fabricated with N719 as the detector.

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The obtained results revealed distinct trends based on the compatibility between the dye sensitizer in the dye-sensitized solar cells (DSSCs) and the dye present in the sample solution: In matched systems, where the DSSC and the analyte solution contained the same dye, a nonlinear relationship was observed between dye concentration and output voltage. The response followed an exponential trend, indicating high sensitivity of the DSSC to concentration changes at lower levels, but reaching a saturation point at higher concentrations. This behavior suggests that DSSCs can serve as effective detectors for analytes with molecular structures similar to their incorporated dye sensitizers.

In mismatched systems, where the DSSC and the analyte solution contained different dyes, the system response conformed to the Beer-Lambert law, exhibiting a linear correlation between dye concentration and output voltage. This linearity confirms the capability of DSSCs to function as spectroscopic sensors, particularly when the dye in the cell differs from that in the sample.

The performance of the DSSCs was also evaluated under different light sources, including sodium, mercury, and tungsten lamps. The highest output voltage was recorded under tungsten illumination, indicating that the spectral characteristics of tungsten light are more effectively aligned with the absorption profiles of the selected dyes.

These results demonstrate that the photovoltaic behavior of DSSCs is strongly influenced by the spectral range of the incident light. Tungsten lamps, which emit a broad spectrum, appear to provide optimal excitation for the dyes used in the DSSCs. The spectral overlap between the tungsten emission and the dye absorption likely enhances photon absorption, leading to higher output voltages. This finding underscores the importance of matching the light source to the absorption characteristics of the dye to maximize DSSC performance in practical applications.

In summary, the findings confirm that dye-sensitized solar cells (DSSCs) can be employed as versatile optical sensors for both quantitative and qualitative chemical analyses. Leveraging their responsive behavior, DSSCs offer an innovative approach to concentration determination, eliminating the need for conventional monochromators or photodetectors.

4. CONCLUSIONS

While UV-Vis spectroscopic method is common for quantitative measurements, dye-sensitized solar cells (DSSCs) can serve as an alternative approach, particularly for analyzing dyes. They offering a different avenue for quantitative analysis compared to traditional spectroscopic techniques. A simpler, cheaper and yet sensitive route.

The research results showed that by selectively synthesizing the dye-sensitized solar cells, it can be easily used instead of a detector in spectroscopic devices, taking advantage of the economic benefits and great versatility of these simple devices. So far, no study has been conducted on the use of these simple and accurate tools for quantitative measurements instead of expensive detectors in spectroscopic devices. We hope that this research will be an introduction to further applications of DSSCs as the dedicated detectors.

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University, Tehran, Iran.

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سلول‌های خورشیدی حساس‌شده با رنگ با استفاده از برخی رنگ‌های آلی به عنوان حسگرهای نوری: ابزاری جدید و کارآمد برای تجزیه کمی

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چکیده

در این مطالعه، یک روش نوین برای اندازه‌گیری کمی مواد با استفاده از سلول خورشیدی رنگدانه‌ای (DSSC) ابداع گردید. ماده مورد مطالعه به عنوان رنگدانه در سلول خورشیدی حساس شده با رنگ (DSSC) به کار گرفته می شود و این سلول به عنوان آشکارساز برای شناسایی کمی ماده هدف عمل می‌کند. محلول نمونه مورد بررسی به طور همزمان در معرض تابش تمام طول موج‌های یک لامپ تنگستن قرار می‌گیرد و یک سلول خورشیدی که به عنوان آشکارساز عمل می کند، میزان جذب را ثبت می‌کند. این سامانه از نظر طراحی مشابه یک طیف‌سنج نوری ناحیه مرئی- فرابنفش است با این تفاوت که از تکفام‌ساز استفاده نمی‌شود و این جزو مزایای این روش ساده است. در این مطالعه، چهار نوع سلول خورشیدی با استفاده از رنگ‌های مختلف N719) و Bromo ethylene Blue و Quinalizarin و 2,7- Dichlorofluorescein) ساخته شد. با جایگزینی این سلول‌های خورشیدی با آشکارساز طیف‌سنج UV-Vis، شدت جذب نور لامپ تنگستن برای محلول‌های حاوی رنگدانه مورد استفاده در سلول خورشیدی و سایر رنگ‌ها بررسی شد. مشاهدات نشان می دهد که اگر محلول مورد بررسی با رنگدانه استفاده شده در سلول خورشیدی همسان باشد، میزان جذب متناسب با لگاریتم غلظت خواهد بود. اما اگر محلول حاوی رنگ متفاوتی با سلول خورشیدی (نا همسان) باشد، پاسخ سامانه از قانون بیر-لامبرت پیروی کرده و رابطه‌ای خطی با غلظت نشان می‌دهد. این روش می‌تواند برای شناسایی کمی و کیفی مواد مورد استفاده قرار گیرد. در تحلیل‌های کیفی و کمی، DSSC منحصر به فرد ساخته‌شده با رنگ نمونه به عنوان آشکارساز برای هر نمونه به کار می‌رود.

کلید واژه ها

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