NANOMATERIAL MIXED WITH DYES TO MAKE SOLAR CELL CONCENTRATOR

Najlaa Mohammad Hadi*
Department of Physics, College of Education for Pure Sciences, Babil, Iraq,
*corresponding author: Pure.najlaa.hadi@uobabylon.edu.iq
https://orcid.org/0000-0001-8632-8813

Adnan Falh Hassan
Department of Physics, Faculty of Science, University of Kufa, Najaf, Iraq,
adnan.aljubry@uokofa.edu.iq
https://orcid.org/0009-0006-0107-5057

Talib Mohsen Abaas
Department of Physics, College of Education for Pure Sciences, Babil, Iraq,
Pure.Talib.Mohsen@uobabylon.edu.iq
https://orcid.org/0000-0003-4921-9962

Highlight

Dyes to make solar cell concentrator.

Abstract

In the present work, different concentrations of natural dyes (pomegranate, saffron, black lemon) were prepared by solving (0.001,0.002,0.003) g from these dyes in 100ml of pure water. The preparation of different concentrations mixed with the nanomaterial (titanium oxide) at a rate of 0.9 grams per 100 ml of pure water, in addition to mixing it with polymer epoxy resin at a ratio of 2:1 to obtain a solid mold after leaving it for two days to dry, and four solar cells were placed on the four different of the blocks which manufacture as solar cell concentrator. The best value for the efficiency of the solar cell was found for the pomegranate dye with a concentration of 0.002 grams, which is (η=1.232), while the efficiency of the solar cell without dye is (η=0.500).

Keywords

dyes; solar cell; nanomaterial.

Introduction

Solar photovoltaic, also known as photovoltaic cell. Initially referred to as a solar battery, the term now holds a distinct interpretation. A device that directly converts solar energy into electrical energy by utilizing the photovoltaic effect. The structure includes a silicon layer with added impurities to provide specific electrical characteristics. Phosphorus is added to the upper layer facing the sun to enable it to pump electrons when exposed to light. The layer is referred to as the n-layer, and the presence of boron in the lower layer enables it to absorb electrons. This stratum is referred to as the P-layer. When solar radiation reaches the upper layer, electrons receive energy proportional to the solar radiation's intensity. When an electrical conductor connects the two layers, electrons flow from the upper layer to the lower layer, creating an electrical current and voltage [1]. Great potential for combining with solar cells to address primary issues related to non-absorption and thermalization losses [9]. The active photoluminescent layer is applied to a completed solar cell to absorb solar photons that were not effectively captured and convert them into more suitable wavelengths. Solar cells are a crucial energy source for powering spacecraft and satellites. Electricity is regarded as one of the supplementary options to conventional energy sources like oil, coal, and gas, which are finite and at risk of depletion due to extensive use. Solar cells directly convert solar energy into electricity without causing environmental pollution and have a lifespan of up to 30 years. The primary hindrance to its utilization is the exorbitant production expenses. Luminescent solar cell (LSC) High-energy solar photons are absorbed by the luminophores on the plate and then re-emitted at longer wavelengths. Some of the light produced is directed through total internal reflection (TIR) to the waveguide's edges, where connected PV cells gather and transform the light into electricity.

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Luminescent solar concentrators (LSCs) are beneficial because they can capture sunlight across large areas and focus it onto smaller areas, reducing the need for a large number of photovoltaic cells and making high-efficiency cells more economically viable [10].

Experimental

Three dyes were extracted from different plants (pomegranate, saffron, and black lemon) after preparing them by dehydration method, where the plant was cut, placed in water, and boiled at 65 degrees Celsius, which resulted in 20 percent of the water being eliminated to preserve the smell of the plant. Finally, dehydration was performed in a dryer (oven). At 65°C for 11 hours a dry paste was obtained and then crushed to obtain a powder.

After that, it is dissolved in an amount of (0.001,0.002,0.003 g) in 100 ml of pure water, adding 0.9 g of nanomaterial (titanium oxide) according to equation (1)[2], mixing it with epoxy resin in a ratio of 1:2, placing it in a mold measuring (7 * 7 * 3)cm^3 and leaving it to dry for two days and making the cell As in the figure (1). The solar cell was placed on four walls of the mold and illuminated with a 300-watt electric lamp to calculate the efficiency of the solar cell by device Solar Module Analyzer before placing the mold and after placing the mold. It was found that the efficiency of the cell before placing the mold η = 0.500 %.

$$C = \frac{WX1000}{MwXV} \quad (1)$$

Where:

C: the Mgo concentration

W: is the weight of the Mgo (in grams)

Mw: Molecular weight of the MgO

V: the volume of the solvent (ml)

Figure 1. LSC prepared panels of all dyes

Material Included

Natural coloring comes from plants like (pomegranate, saffron, and black lemon).

Anthocyanin molecules found in these plants absorb light at visible wavelengths, allowing them to absorb photons [11].

Nanomaterials describe, in principle, materials of which a single unit is sized (in at least one dimension) between 1 and 100 nm [12].

1. Black Lemon Dye

Black lemon is an inorganic black dye. Figure (2) shows the chemical structure of the Black Lemon dye and lemon fruits.

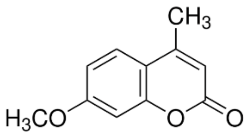

Figure 2. Chemical structure of Black lemon dye [3]

2. Pomegranate Dye

Pomegranate is an inorganic red dye. Figure (3) shows the chemical structure of the pomegranate dye and pomegranate fruits.

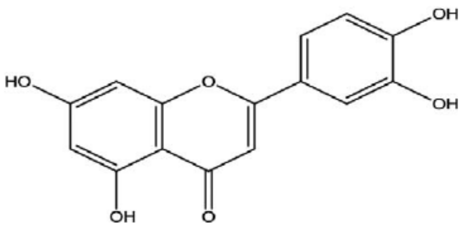

Figure 3. Chemical structure of pomegranate dye [4]

3. Saffron Dye

Saffron is an inorganic yellow dye. Figure (4) shows the chemical structure of the Saffron dye and Saffron plant.

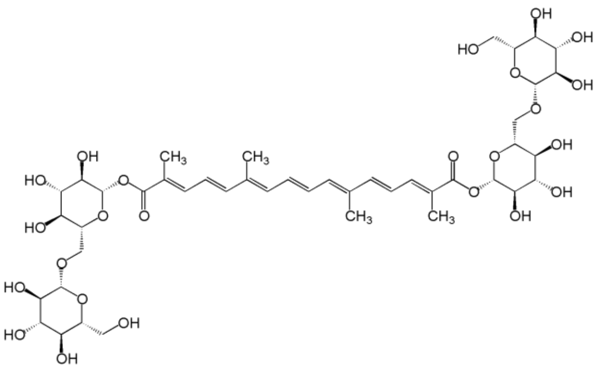

Figure 4. Chemical structure of Saffron dye [5]

4. Titanium Oxide

Titanium Oxide is the inorganic compound with the chemical formula TiO_2 [6]. Nontoxicity, chemical stability, poor solubility, and high refractive index are properties that add to their practical applicability IN figure (5) [13].

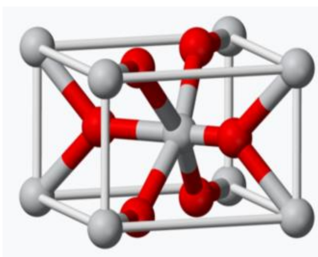

Figure 5. Titanium oxide structure [6]

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5. Polymer (Epoxy Resin)

Polymer Epoxy consists of two materials. The first substance is referred to as "hardener," while the second substance is known as "epoxy resin." This polymer is completely reactive to acids, bases, and solvents. When dry, it forms an insulating layer that aids in interlocking polymer chains when combining two materials. The ratio at which these two materials mix varies depending on the type of epoxy. The research utilized a 2:1 ratio of hardener to epoxy resin.[7]. It has severe adhesion and abrasion resistance. Acids bases or solvents are chemical materials. They are used as basic materials for making fluorescence panels. They are prepared as liquids with a low viscosity, transparent color, solidification at room temperature, moisture-proof, effect of chemicals, and high flexibility IN figure (6) [8].

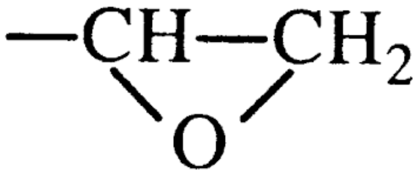

Figure 6. Chemical structure of Epoxy group

Instruments

1. Solar Cell

Mono-crystalline silicon solar cell of type (F-TNY1180) has been used Its dimensions are (3 × 7) cm^2 and its efficiency is (η=0.500).

2. Experiment Setup

Figure 7 shows the setup of the system hardware. The distance between the solar cell and the light source was adjusted and fixed to get 1.5 AM. The solar cell analyzer was used to measure the voltage, current, fill factor, and solar cell efficiency. These measurements can be obtained from Personal a computer connected to the solar cell analyzer Also, a current-voltage curve can be obtained.

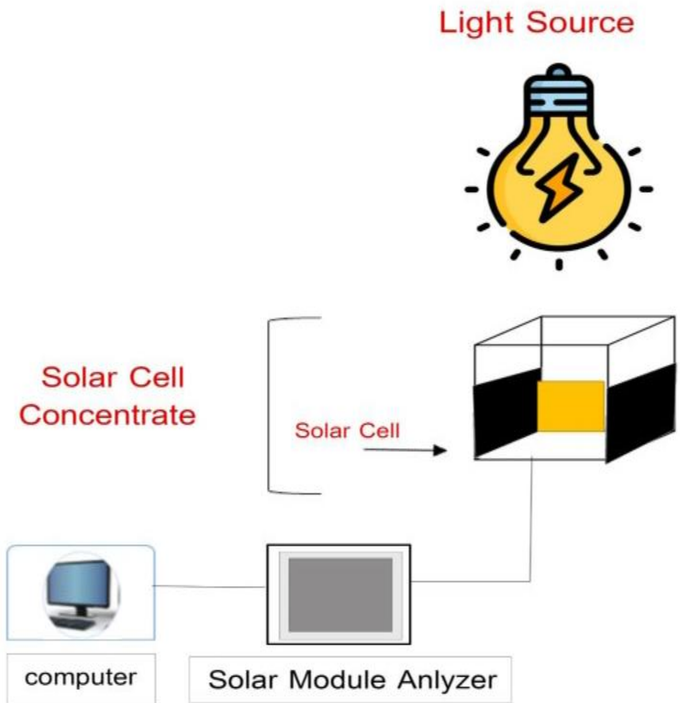

Figure 7. Setup of the experiment hardware

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Results and Discussion

1. Scanning Electron Microscope (SEM)

The SEM of the nanomaterial (TIO_2) was measured for several reasons, including: It can reveal fine details of the surface structures of nanomaterials, including crystal structures, distortions, and defects.

High-Resolution Imaging: SEM provides high-resolution imaging of samples with nanometer resolution, allowing small details to be seen precisely.

Imaging under multiple angles: SEM can capture images of samples under multiple angles, allowing a better understanding of the 3D structures of nanomaterials As in the figure (8).

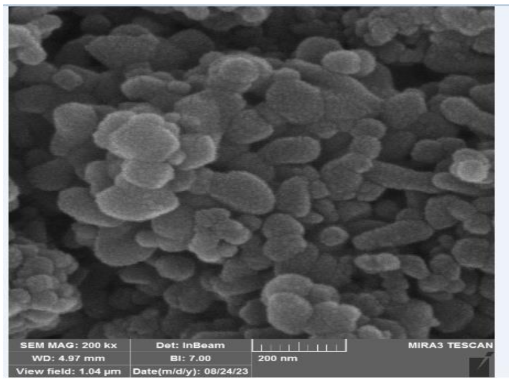

Figure 8. SEM of the nanomaterial (TIO_2)

2. Transmission electron microscopy (TEM)

A transmission electron microscope (TEM) is an advanced instrument used to study structures and details at the nanometer level. For nanomaterials, TEM offers several important benefits and possibilities:

Analysis of nanostructures: TEM allows the analysis of material structures at the nanometer level, and thus can reveal fine details and nanostructures.

Analysis of the arrangement of atoms: TEM can show the arrangement of atoms in nanomaterials precisely, and thus can be used to study crystallography and atomic arrangement.

High-resolution imaging: TEM provides high-resolution images of samples, allowing fine details to be seen clearly.

Chemical composition analysis: TEM can combine its high-resolution images with chemical element composition analysis using the electron emission sum (EDS) technique as in Figure (9).

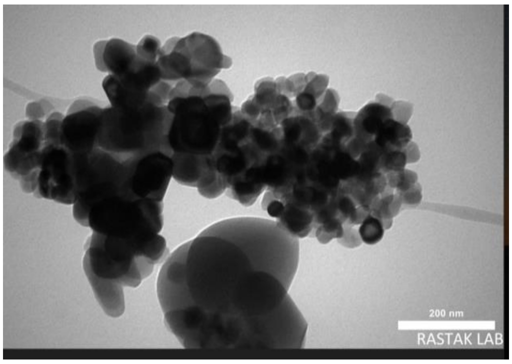

Figure 9. TEM of the nanomaterials (TIO_2)

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3. Solar Cell Efficiency

A tables showing the calculation of the efficiency of the solar cell for each dye, with the Maximum current, the Maximum voltage, and the fill factor, which was calculated using a Solar Module Analyzer.

Table 1. Solar Cell Efficiency (η) of Mixture (Pomegranate Dye and Titanium Oxide) at Different Concentrations

Weight ratio	**Nanomaterial**	**V_{max}**	**I_{max}**	**FF**	**η%**	**ηΔ%**
0.001	Tio_2	4.399	42.20	0.807	1.189	1.378
0.002	Tio_2	4.274	45.00	0.746	1.232	1.464
0.003	Tio_2	4.135	42.00	0.749	1.113	1.226

Table 2. Solar Cell Efficiency (η) of Mixture (Saffron Dye and Titanium Oxide) at Different Concentrations

Weight ratio	**Nanomaterial**	**V_{max}**	**I_{max}**	**FF**	**η%**	**ηΔ%**
0.001	Tio_2	4.060	45.30	0.761	1.178	1.356
0.002	Tio_2	4.043	44.80	0.714	1.161	1.322
0.003	Tio_2	4.262	40.60	0.774	1.109	1.218

Table 3. Solar Cell Efficiency (η) of Mixture (Black Lemon Dye and Titanium Oxide) at Different Concentrations

Weight ratio	Nanomaterial	V_{max}	I_{max}	FF	η%	ηΔ%
0.001	Tio_2	4.062	43.90	0.730	1.143	1.286
0.002	Tio_2	4.060	42.70	0.715	1.111	1.222
0.003	Tio_2	4.128	41.90	0.811	1.108	1.216

We note from the tables above that the highest value of solar cell efficiency is for pomegranate dye at a concentration of 0.002 g, where it is equal to Δη=1.464 %.

It was found that the efficiency of the cell before placing the mold η = 0.500.

This increase in solar cell efficiency is due to several reasons:

1. Reduce light reflection: The glass surfaces of the solar panel may reflect part of the incoming light onto the cell instead of absorbing it. If a thin layer of nano-mixed epoxy resin is applied to the surface, this layer can reduce reflections and increase the light absorption rate.
2. Light directing: Some nanomaterials are used to direct light towards the surface of the solar cell, which increases the chance of absorbing light and increasing efficiency.
3. Increase contact area: Nanomaterials can increase the contact area between the solar cell and the added nanomaterials. This increases the chance of light interacting with the cell, increasing solar performance.
4. Reducing heat loss: Some nanomaterials can help reduce heat loss from the solar cell, reducing its heating and improving its efficiency.
5. Improved electrical resistance: Nanomaterials can be used to improve the electrical resistance of a solar cell, reducing energy loss while converting light into electricity.

In summary, the addition of nano-mixed epoxy resin can improve the efficiency of a solar cell by increasing light absorption and reducing electrical and thermal losses, increasing electricity production, and improving its overall performance.

Conclusion

We conclude that the absorbency of natural dyes increases with increasing concentration of the dye. We conclude that adding nanomaterial to the dye increases the absorbency of the dye. The making of a light center consists of epoxy resin in addition to nanomaterial. The dye leads to an increase in the absorption of light, prevents its scattering, and unifies its direction, and this increases the efficiency of the solar cell.

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