Solar Cells Stimulated by Pigments Extracted from Natural Flowers

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Abstract. In this research, the film of solar panels had been prepared from three organic pigments extracted from the Rosy and Yellow gori flowers and from the violet flowers, by a method of converting the leaves of these flowers into powder in a powdery form, in the laboratory at room temperature, as luminescent solar concentrators to improve the conversion efficiency of solar cells. The transmittance and absorption for this pigments extracts are very good, it has an ability to absorb a high quantity from the sun light, and the results show considerable contribution of the panel and thin film to enhance the efficiency of the solar cell.

So, through present work, measurement were carried out for the concentration of solvent for each of the three pigments extracts, considering the concentration for each pigment is constant. It was found that mixing between the three extracted pigments was the best, as it gave a higher absorbency and permeability, and that is what also have been found with the thin film prepared from the mixed pigments. As it gave a clear and high increase in the efficiency of the solar cell with a small thickness, and this calls for the use of mixed pigment solutions as a layer of dye solar cells.

Key words: Solar, cells, Organic Pigments, Powdery form

1. Introduction
The second generation of thin film solar cells are considered more economical when compared to the first generation of silicon solar cells because the second generation contains thin films (generally of 1 micrometre thickness) with very light absorption layers, while the third generation of solar cells are considered promising new technologies such as cells of Nano-based solar cells, dye-based solar cells, polymer-based solar cells, and concentrated solar cells [1].

There are different types of materials to absorb the sun's rays, including organic materials such as conjugated polymers and conductive organic pigments that are very sensitive to sunlight, so they absorb sunlight on the basis of the principle of light effect, causing the conversion of electromagnetic radiation energy into electrical energy [2]. These materials, with their high ability to absorb solar radiation, give solar cells an efficiency that ranges between 3-10% and their cost is 50% less than that of silicon solar cells, but they do not work well at high temperatures [3]. Light-sensitive pigment preparations act as a light absorbent in concentrated solar cells and dye-solar cells because of their main characteristic of high absorption of sunlight, some of which are organic pigments and others are inorganic [4].

Rosa damascena L is the Queen of Roses because of its beautiful sight and aromatic scent. This plant belongs to the Rosales order, the family of Rosaceae, the genus Ros, which includes up to 75 species.
and varieties, and its scientific name is *Rosa* [5]. Figure 1 shows the form of the Rosy and yellow gori flowers as used.

![Figure 1. The Rosy and Yellow gori flowers](image)

Violet flower is one of the plant species capable of producing flowers of a purple or white colour, as there are approximately five hundred species of this plant in various parts of the world, the scientific name is *Viola* [6]. Figure 2 shows the form of the viola used.

![Figure 2. The Violet flower](image)

This research deals with preparing organic dyes from locally available natural flowers that are sensitive to sunlight, which are used as catalysts for solar cells to increase their efficiency, such as concentrated solar cells, as well as dye solar cells based on organic stimulating dyes.

2. Materials and methods

2.1. Preparation of powder pigments of flowers:

Three pigments were extracted from the Rosy, Yellow gori and the violet flowers, respectively, through converting their leaves into powders in a powdery form. Likewise, the three pigments were mixed resulting in pigments of other colours that are different from the original ones. These pigments are considered organic because they were produced from flowers or organic plants.

After plucking a group of Rosy and Yellow gori flowers, as well as violet flowers, washing them well with water, then placing them under the sun's rays to dry and stiff for five days, while covering them with a light clip to prevent dust and particles of dust falling on them, and then crushed the stained flowers with a pottery mill to have crushed fine as becoming. Figure 3 shows the pigments prepared in powder form.
2.2. Preparation of pigments solutions with different concentrations
Using a sensitive scale, a weight of a small portion of each of the three pigment powders was measured with specific weights, then each weight of each of the three pigments was dissolved in (5 ml) of Acetone alcohol to produce extracted pigment of that flower. It may be worth to mention that, Acetone alcohol was much better to solve the three prepared pigments as compared with Ethanol and distilled water solvent mix which did not dissolve the pigments properly. The following formula was adopted for measuring the concentration of a given solution [7]:-

\[
W = \frac{M_W \times V \times C}{1000}
\]

Where:
- \( W \): weight of the dissolved pigment (g)
- \( M_W \): Molecular weight of the dye (g/mol)
- \( V \): Volume of the solvent (ml)
- \( C \): Dye concentration (mol/L)

Three solutions (extracts) of the three pigments were obtained with different concentrations. Also, each of the Rosy and Yellow gori pigments was mixed with the Violet pigment to produce mixed pigments of Rosy + Violet and Yellow gori + Violet pigments. Figure 4 shows the three extracted pigment solutions (dyes) of Rosy, Yellow and Violet flowers, while Figure 5 show the solutions of the two mixed pigments of Rosy + Violet and Yellow gori + Violet.

**Figure 3.** Pigments prepared of Rosy, Yellow and Violet flowers in powder form.

**Figure 4.** Pigment solutions of Rosy, Yellow and Violet flowers
Figure 5. Solutions of Rosy + Violet and Yellow gori + Violet pigments.

Table (1) lists the characteristics of the pigments (dyes) prepared and adopted in this work.

| Dye flower origin | Symbols | Concentration (mol/L) | λ max(nm) Abs. | λ max(nm) Trans |
|------------------|---------|-----------------------|----------------|-----------------|
| Rosy             | R       | $1 \times 10^{-5}$    | 550 nm         | 630 nm          |
| Violet           | V       | $2 \times 10^{-5}$    | 545 nm         | 625 nm          |
| yellow           | Y       | $3 \times 10^{-5}$    | 540 nm         | 635 nm          |
| Yellow + Violet  | YV      | $2 \times 10^{-4}$    | 670 nm         | 645 nm          |
| Rosy + Violet    | VR      | $1 \times 10^{-4}$    | 680 nm         | 645 nm          |

2.3. Preparation of the thin film
In preparation of the thin film, a method of coating the permian where precipitation pigment solvent on the museumbrane glass by technique spin coater model VTC–100 which is compact Spin Coater 500-800 rpm with two programmable segments [8]. The system used in measurement included the solar cells, solar module analyzer, prochrcter, density flux (550 watt/m²) falls on the solar cell with the thin film and computer [9]. An electronic (digital) caliper used in measuring the (thickness) of the thin film [10]. Crystalline silicon solar cell type (F – TNY 1180) having square – shaped, with dimensions of $75 \times 75 mm$, efficiency of (η: 4.190%) [11] has been used. For the measurement of the parameters of solar cell like; efficiency, voltage, current and fill factor, the solar Module Analyzer of brand prove 200 equipped with PROVA instruments belong to INC company [12] has been used. Figure 6 shows the digital electronic caliper, silicon solar cell and solar Module Analyzer.

3. Results and discussion
3.1 Measurement the absorption spectra.
The absorption spectra for the three pigments extracted from Rosy, yellow gori and Violet are shown in figure 8. The three pigments showed absorption intensity that increases with a little shifting towards higher wavelengths keeping concentration as constant. Figure 9 shows the absorption spectra for the mixed dyes.
Figure 6. The digital electronic caliper and silicon solar cell used.

Figure 7 shows the thin film as luminescent solar concentrators prepared from solvent of the mixed powder to the two dyes Violet+ Rosy in $2 \times 10^{-4}$ Concentration (ml).

Figure 7. The thin film prepared with thickness of 0.21mm.
3.2 Measurement of the transmission Spectra.
Transmittance and spectroscopy means the passage of a part of the incident light ray at a specific wavelength through the sample. This is why the concept of transmittance depends on the property of the material and the thickness of the material in particular. So, the more thick the material, the less transmissible light permeability corresponding to the concept of absorbance, which means the sample's absorption of a portion of the incident light ray at a specific wavelength [13].
There are slight differences between values of the transmission for the three pigments. Generally, the transmission increased with the increase of wavelength within visible region. Figure 10 shows the optical transmission spectra of the three pigments.

![Figure 10. Optical transmission spectra of the three pigments.]

3.3 The solar cell efficiency

When installing the thin film on the solar cell, the cell efficiency ($\eta$) increased with rise in the values of current – voltage. Figure 11 shows the efficiency ($\eta$) of solar cell with the current – voltage curves by using the thin film for pigments.

![Figure 11. The efficiency ($\eta$) of solar cell with thin film.]

The table 2 explain the value of the efficiency ($\eta$) of the solar cell with installing the thin film for the pigment (VR). According to result shown in table 2, the efficiency obtained for the solar cell having thin film with constant thickness increased from (4.190 to 6.995)% due to the effect of the thin film.
Table 2. The solar cell efficiency by using the thin film for VR pigments

| Sample                  | Thickness (mm) | Concentration (mol/L) | %ŋ   |
|-------------------------|----------------|-----------------------|------|
| Thin film of VR pigments| 0.21           | $2 \times 10^{-4}$    | 6.995% |

4. Conclusions.

The pigments which extracted were good pigments, because they have a relatively high absorption and transmittance in the visible region. Acetone is a good solvent to the Rosy, Yellow, and Violet pigments. The thin film of the pigment extraction from VR pigments raise the efficiency of the solar cell from (4.190 to 6.995) %, with rise in the values of current – voltage for cell solar. So the efficiency of solar cell increases when the thickness and concentration of films decrease. The extracted pigment may be used as one layer or two layers in the multilayer solar cell and use as a Luminescence Solar Concentrators (LSC) to improve the solar cell efficiency.

5. References.

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