Journal of Physics: Conference Series

PAPER • **OPEN ACCESS**

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To cite this article: Dhafer Manea Hachim AL-Hasnawi *et al* 2018 *J. Phys.: Conf. Ser.* **1032** 012023

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Novel Technique for Photovoltaic Solar Cell Efficiency Enhancements by Coating with Chlorophyll

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Abstract. In this paper a novel technique proposed and implemented practically for photovoltaic cell efficiency enhancements. It is known that Iraq is one of the hottest countries in the world. It has a solar insolation average and energy higher than that of most of other countries. Solar photovoltaic cell has a limited efficiency boundary, which is affected by the amount of absorbed solar heat (energy). It is found that; when the solar array temperature excess 70 C^0, the photovoltaic solar cell efficiency will be decreased remarkably. This novel technique which include painting the solar cell surface with chlorophyll only one time and painting it's surface with chlorophyll and polymer mixture another time gives a perfect solution to get a wide band of solar temperature array with a remarkable efficiency enhancement. The experimental results show that coating solar cell surface with chlorophyll only increases its efficiency by 5.5 % which is the maximum increase, while coating solar cell surface with chlorophyll and polymer mixture increases its efficiency by 3.1 % only.which is less than increase in the first case but more than that of solar cell without coating. All cells tested at constant solar irradiation (I=1000 W/m^2), and variation of temperature in range (30 ^oC to 80 ^oC).

1. Introduction

As a great potential renewable energy source, solar energy is becoming one of the most important energies in the future. Recently, there has been an enormous increase in the understanding of the operational principle of photovoltaic devices, which led to a rapid increase in the power conversion efficiencies of such devices. Solar cells vary under temperature changes; the change in temperature will affect the power, output from the cells. Garca M.C. and Balenzategui J.L. (2004) [1] used many different PV modules to simulate nominal operation cell temperature (NOCT)for building integration applications, where the yearly modules temperature and performance for different orientations and tilted angles were presented. Islam M.D. and etal (20090 [2] conducted a study to show that Abu Dhabi has a strong potential for solar energy capture by measuring the solar radiation and surface temperature for one year. Yassine Charabi and Adel Gastli (2013)[3] used fuzzy logic and GIS-based spatial multi-criteria evaluation to conduct an investigation on siting large PV power plant to study the effects of temperature and dust on the performance. Schwingshackl C. and etal (2013)[4] investigated the change on PV panels temperature by the influence of natural wind cooling and showed that including wind data in the analysis leads to better results and prediction. Cuce E. and etal (2013)[5] presented a study addresses statistical and experimental investigation dealing with the effect of temperature within range of 15-60 ◦C and intensity levels of 200-500 W/m^2. The author showed that the current has a proportional relationship to the intensity, whereas the voltage decreases when the temperature increases.

Sanaz Ghazi and Kenneth Ip (2014)[6] conducted an experimental investigation to study the effect of dust density, high humidity, rain and snow on the performance of PV panels in the town of

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Brighton in UK, and showed that these parameters have significant effect and could annihilate any system output.

Goverde Hans and etal (2015)[7] proposed numerous models that can be used to predict the relationship between performance of PV system and solar radiation, ambient temperature and wind. Where they showed that the performance is better when the wind speed and solar radiation increase and poor performance when ambient temperature increases.

Chander Subhash and etal (2015) [8] similar study is presented by Cuce E. and etal (2013)[5] with different ranges, namely 25-60 ◦C for temperature and intensity levels of 215-515 W/m^2. Experimental study the effect of cell temperature in the range 25-60 C at constant light intensities 215-515 W/m^2 on the photovoltaic parameters of mono-crystalline silicon solar cell. The results show that the open circuit voltage, maximum power, fill factor and efficiency are decreased with cell temperature.

Yun Da and Yimin Xuan (2015) [9] conducted a study for temperature effect on performance of solar cells that made of silicon thin-film and found that the performance decreases as the ambient temperature increases. Pierrick Haurant and etal (2015) [10] presented a 3D dynamical model to simulate the steady-state dynamic regimes of PVT collector. Wolff Bjrn and etal (2016) [11] Used support vector regression (SVR) to study various methods of PV power output prediction. Khan Firoz and etal (2016) [12] analytically investigated the effect of ambient temperature on set of PV panels under high solar radiation. Saidan Motasem and etal (2016)[13] investigate the dust accumulation on the PV panels performance in Baghdad-Iraq. Mehmood Umer and etal (2017) [14] a recent work which is presented by Mehmood Umer and etal (2017) [14] investigated the effect of dust and dried mud of the PV modules in the area of Kingdom of Saudi Arabia-Dhahran. Hachim Dhafer Manea and etal (2017) [15] they work experimentally to measure the weather ambient temperatures (DBT), solar intensity and wind speed in Najaf city (Iraq 44 ^{o}E, 31^{o} N) over a period of one year from April 2015 to March 2016, where in present work obtained the measurement weather information of Najaf city of Hachim Dhafer Manea and etal (2017) [15], to find the maximum solar irradiation and temperature reaches during all year, and this date help to test the PV cell in same conditions in Lab.

In this paper experimental investigation, the effect of coating the PV cell by chlorophyll only and mixing (chlorophyll and polymer) at constant solar irradiation and variable temperature on performance of photovoltaic cell to improve it efficiency.

2. Experimental Setup and Procedure

In this work, the experiment includes two main parts. First, the implementation of the chlorophyll in lab. Second part is investigating the performance of photovoltaic cell by measuring the efficiency of PV cell in the laboratory at a constant solar radiation with and without coating the cell by chlorophyll and mixing (chlorophyll and Nitro Cellulose Polymer) Hubeatir K. Abid and etal (20017) [16] Kamil Furkan and etal (2015) [17].

2.1. Implementation of the chlorophyll

The efficiency of cells layers depends on the homogeneity and purity of the natural dye (Chlorophyll) extract. In order to reach this homogeneity, celery samples are extracted through a very accurate operation. First, the samples are washed with pure water, cut into smaller pieces and finely Immersed in ethanol solution. They are blended then filtered to obtain a homogeneous Chlorophyll extract as shown in **Figure 1**.

2.2. Testing PV cell

The PV cell used in this study is 39 x 31.2mm polycrystalline silicon solar cell panel, its power: 0.02W, average voltage: 0.5V, and average current:0.4A as shown in **Figure 2**. Where the solar cell tested at constant solar irradiation (I=1000 W/m^2) with and without coating by chlorophyll and polymer at different temperature by using the following devices in labs. of alternative and renewable research unit in Engineering Technical College of Najaf (as shown in **Figure 3**):

1. Solar irradiation sensor: this device used to measure the solar irradiation.
2. Halogen lamp: this lamp used as solar irradiation source to test the cell.
3. Six T-type thermocouples: these thermocouples used to measure the temperature of cell.
4. Data logger: the device used to record the temperature of cell.
5. Load (variable resistance): this device used to change the load on the cell.
6. Digital voltmeter: this device used to measure the voltage of cell.
7. Digital ammeter: this device used to measure the current of cell.

2.3.Fluorescence Spectrum of Chlorophyll Extracted from Green Celery

The fluorescence spectrum was measured from a wavelength of 200 nm to 750 nm as shown in **Figure 4** the performance of chlorophyll could be obtained by testing the emission of the dye and calculate the energy level distribution. The peaks were observed from 220 nm and 700 nm. The Emission of molecules stimulated at different energized wavelengths. The amplitude of the peaks seen in the emission spectrum is proportion directly to the number of photons that are emitted.

Figure 1. Chlorophyll extract

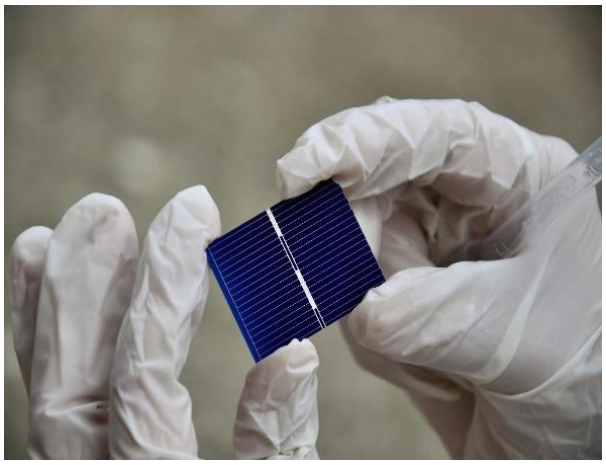

Figure 2. Polycrystalline Silicon Solar Cell Panel

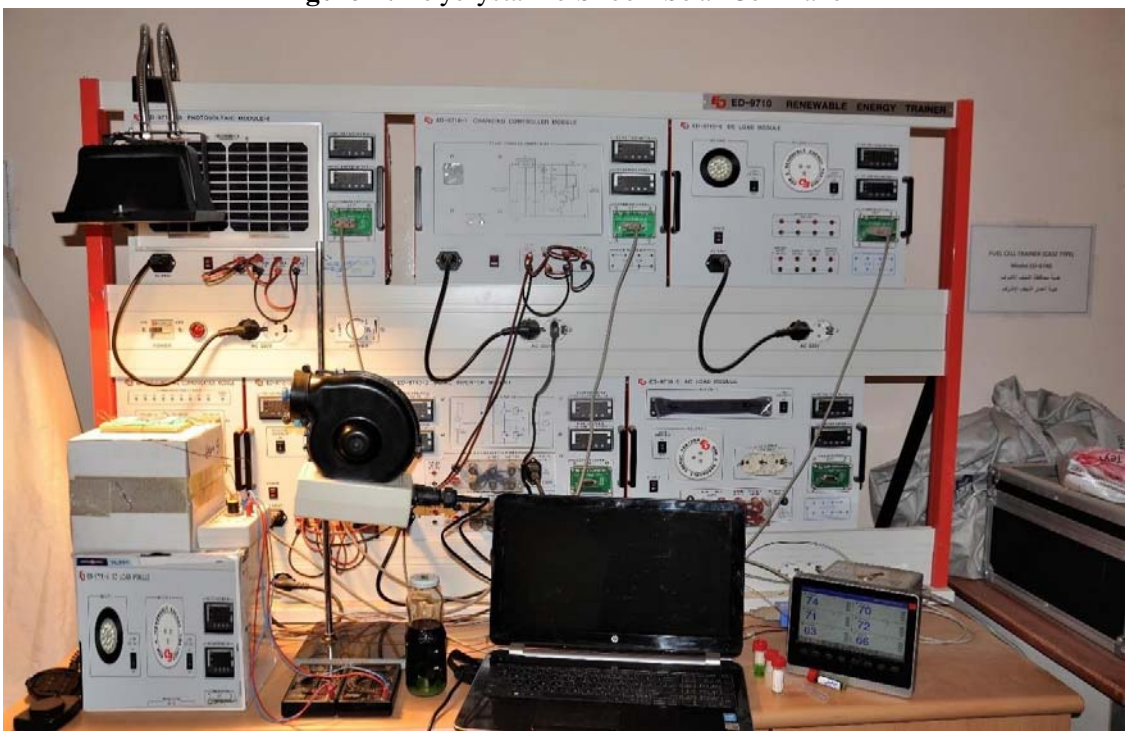

Figure 3. Experimental Rig

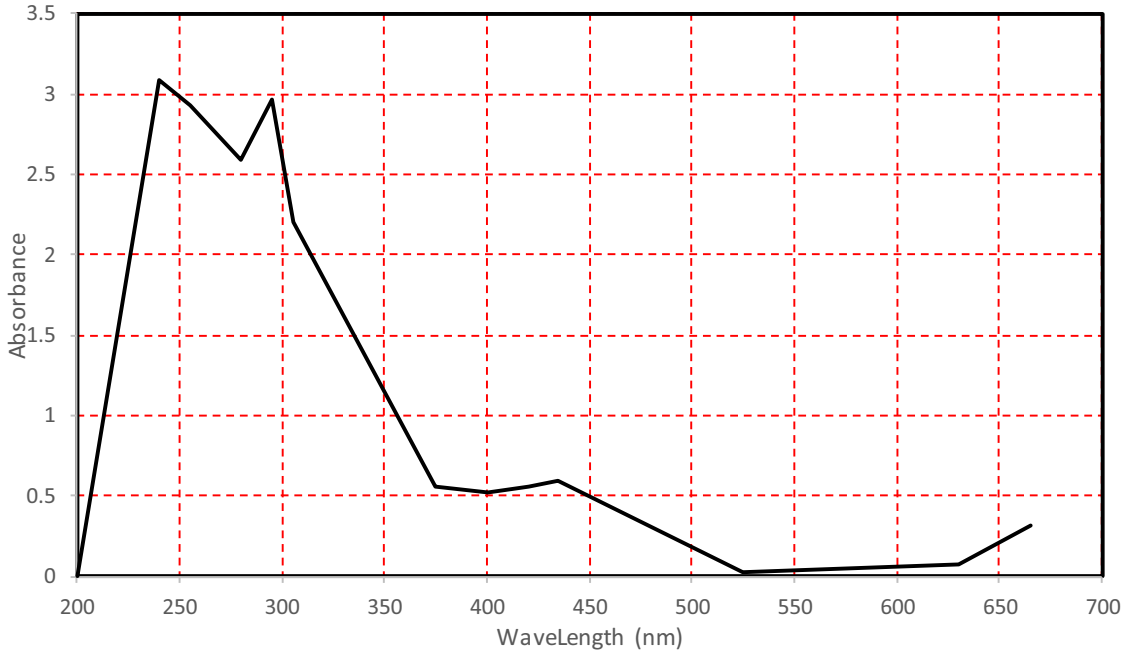

Figure 4. Chlorophyll spectra test results

3. Results and Discussions

The results obtained in this study include the following: Analysis of the data recorded by the photovoltaic system. It also takes data that includes solar radiation, temperatures, voltage, current and power. All this information is drawn and studied its effect on the performance of the photovoltaic system. With and without coating the PV cell by chlorophyll and polymer.

Figure 5 show the relation between the voltage and current output from PV cell at constant solar irradiation and variable load. Where note that the cell coating by chlorophyll only have maximum peak point camper with cell coating with chlorophyll and polymer, and the cell without coating.

Figure 6 and **Figure 7** shows the variation of power with voltage and current at constant solar irradiation and variable load applied on the solar cell. The curves show that the maximum power output is located and this point is called the maximum power point, where this point depending on the load applied on PV cell, so that the curve before and after this point drop, because changing the load applied on PV cell. When tested the three types of cell (coating with chlorophyll only, chlorophyll and polymer, and the cell without coating) at the same conditions. That mean keeping solar radiation and the temperature of solar cell constant. The peak power in power voltage curve for the cell coating by chlorophyll and polymer. While the peak power in power current curve for the cell coating by chlorophyll only. Because the chlorophyll work to decrease the temperature of solar cell and increase the absorbance.

The effect of temperature is the important parameter in present study. So that plot the efficiency variation with temperature at constant solar irradiation and load, by using the line chart as shown in **Figure 8** and using the bar chart for more explanation as shown in **Figure 9**. The cell coating by chlorophyll only have maximum efficiency camper with other cells. Also, the cell coating by chlorophyll and polymer have good efficiency for temperature less than 50 ^{o}C camper with the cell without coating. This happen because the effect of adding chlorophyll and polymer, where the chlorophyll work to

improvement the performance of the solar cell at high temperature and increase the absorbance of sunlight, while the polymer work to keep on the chlorophyll day from outside effect, also make the cell more smoothing and that help to preventing adhesion of dust to the solar cell, thus maintaining its cleanliness and increasing its efficiency.

4. Conclusions

The experimental results show that the power output from solar cell increases with coating by chlorophyll only and chlorophyll and polymer mixture, the efficiency of solar cell increases too also at constant solar irradiation, cell temperature and variable load applied on cell. Then when testing the cell at constant solar irradiation and load with different cell temperature the efficiency of cell coating with chlorophyll only is maximum camper with other cell, the maximum increasing of the efficiency is 5.5 %. While the cell coating with chlorophyll and polymer mixture have less efficiency from the cell coating with chlorophyll only and more than the cell without coating, where the maximum increasing its efficiency is 3.1 %. The cell coating by mixing (chlorophyll and polymer) make the cell more smoothing and that help to preventing adhesion of dust to the solar cell, thus maintaining its cleanliness and increasing its efficiency.

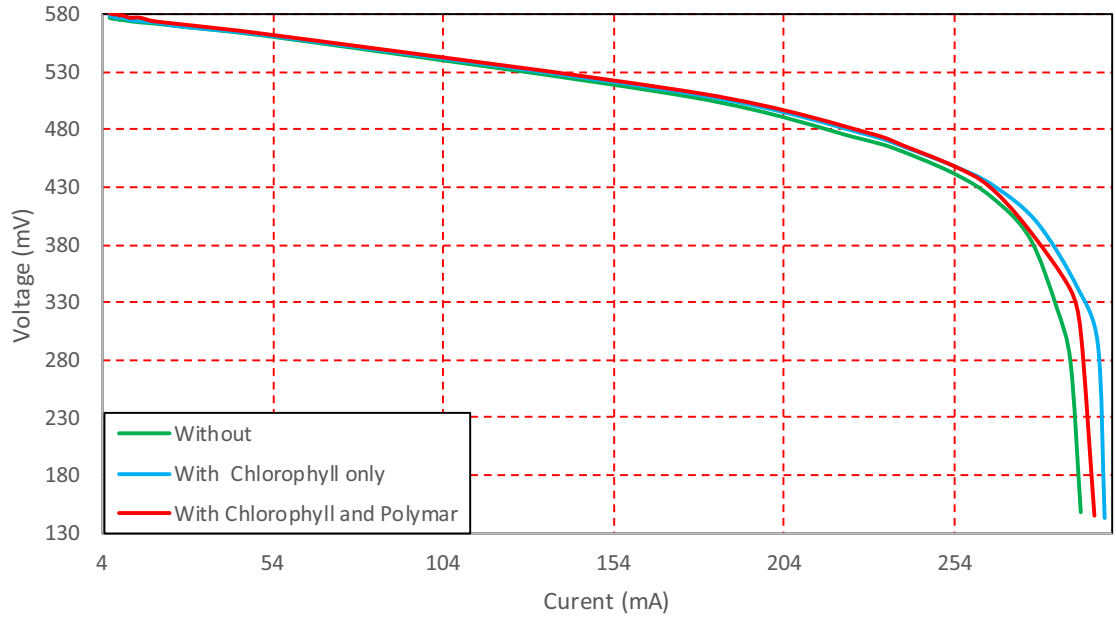

Figure 5. show the relation between the voltage and current output from PV cell at constant solar irradiation and load.

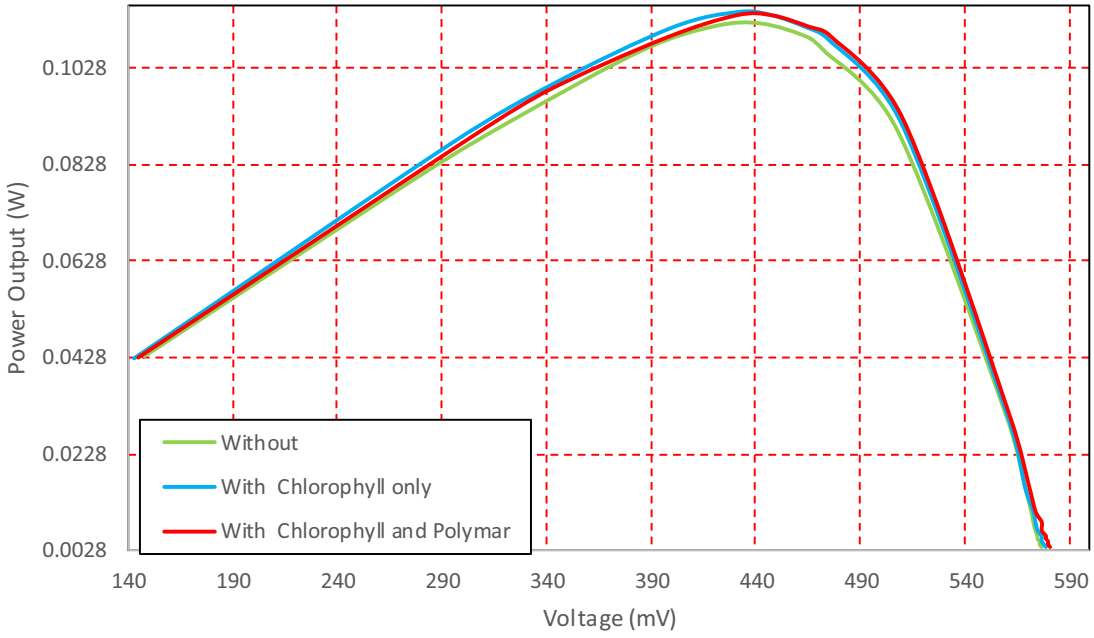

Figure 6. the variation of power with voltage at constant solar irradiation and variable load

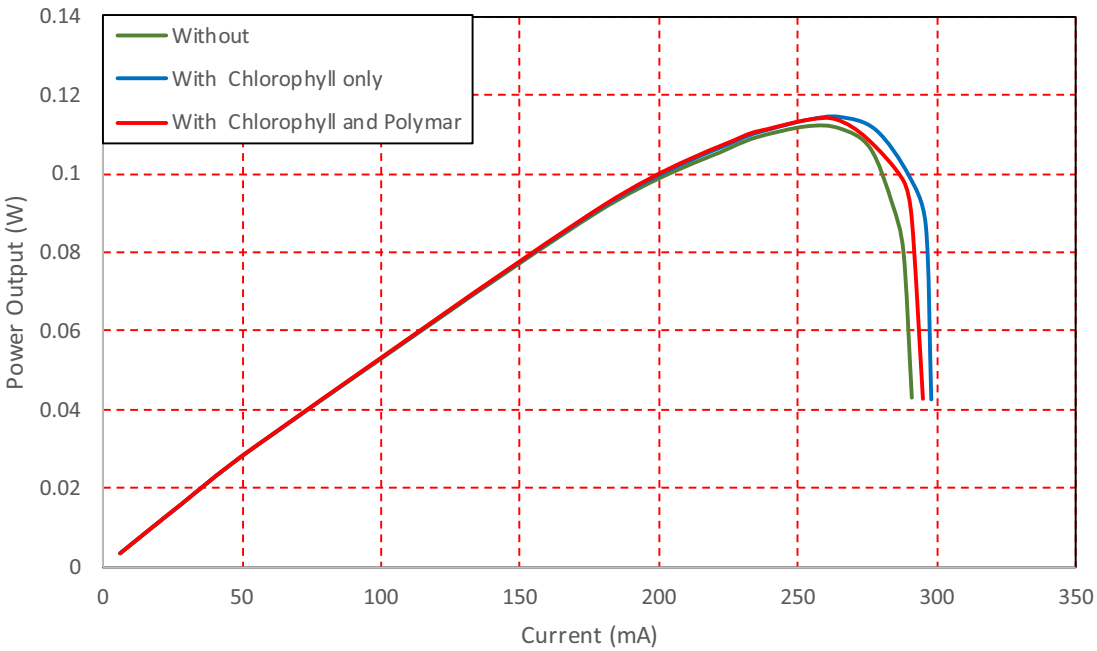

Figure 7. the variation of power with current at constant solar irradiation and variable load

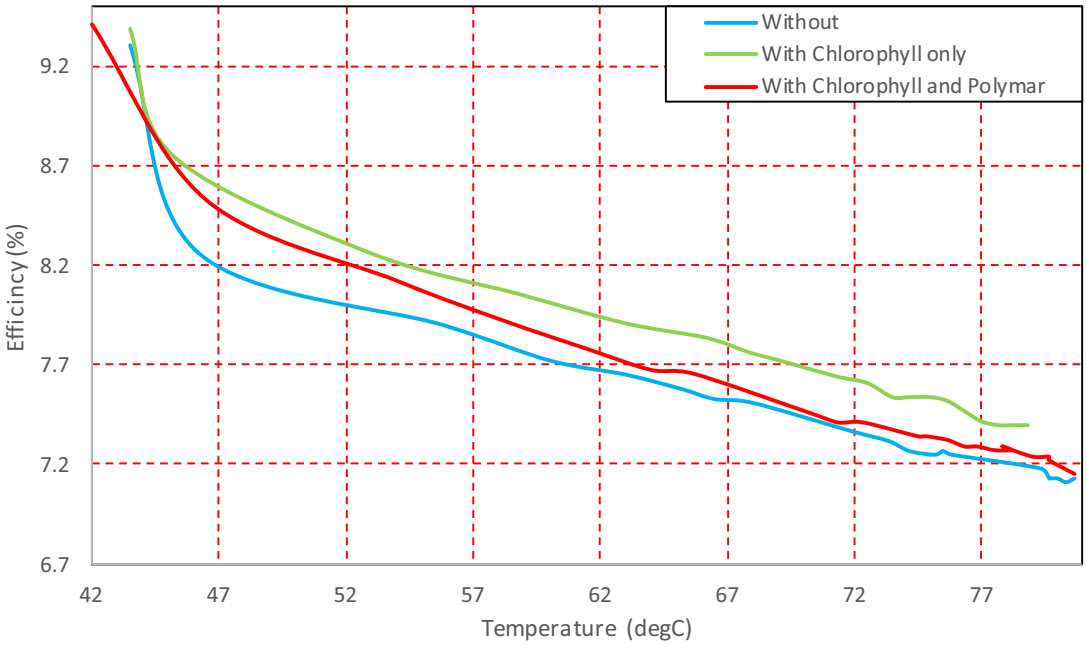

Figure 8. The effect of temperature on the efficiency of cell at constant solar irradiation and load

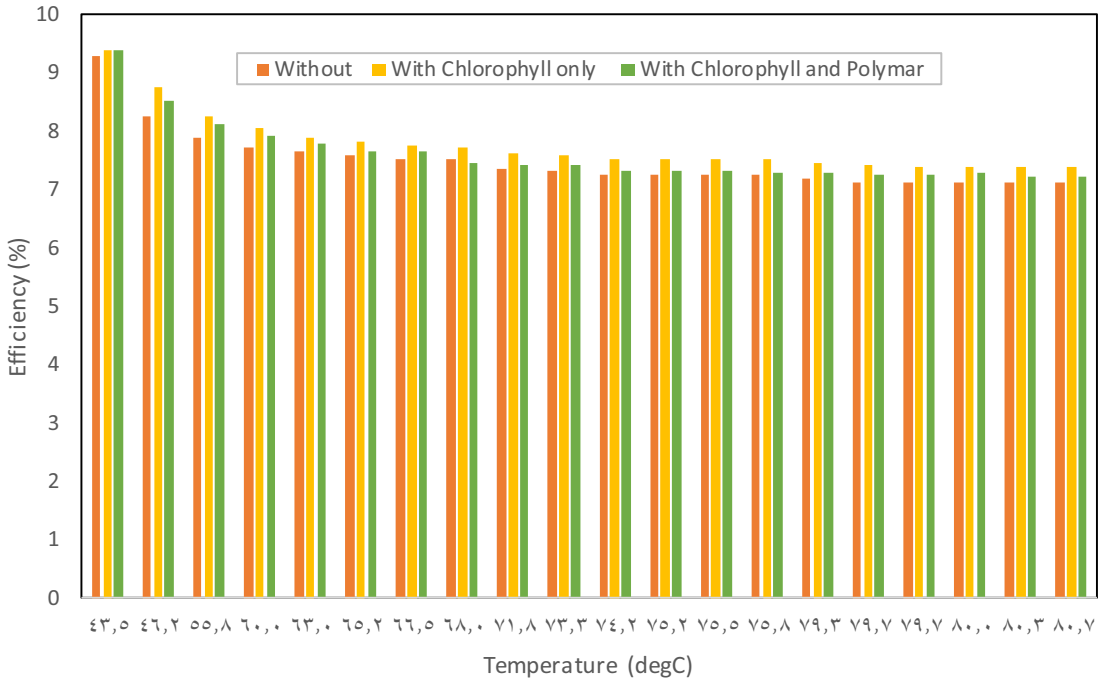

Figure 9. The effect of temperature on the efficiency of cell at constant solar irradiation and load

5. Acknowledgements

We thank our colleagues Professor Dr. Dhakil N.Taha and Professor Dr. Mohammed H. Al-Maamori from university of Babylon who provided insight and expertise that greatly assisted the research.

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