Omdurman Islamic University Journal(OIUJ)
مجلة جامعة أم درمان الاسلامية
https://journal.oiu.edu.sd/index.php/oiuj
https://doi.org/ 10.52981/oiuj.v18i1.1884
2021; 18(1):30-40
ISSN: 5361-1858

Effect of Glass and Plastic Covers on the Performance of Solar Photovoltaic Cells in the Presence of Mud

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To cite this article:
Abdelnabi Ali and, Samah Osman Khairy Ahmed, Effect of Glass and Plastic Covers on the Performance of Solar Photovoltaic Cells in the Presence of Mud, , Omdurman Islamic University Journal, Vol. 18, No. 1, 2022, pp. 30-40, https://doi.org/ 10.52981/oiuj.v18i1.1884.

Received**: 05, 12, 2021;** Accepted**: 1, 16, 2022;** Published**19, 1, 2021.**

Abstract:
With climate change resulting from the use of fossil fuel sources and the increasing use of energy, the sources of renewable energy is growing interest in, which includes direct use of the radiation from the sun through photo-voltaic cells. Photovoltaic solar cell covers in Sudan are exposed during the year to many environmental factors such as rainfall and dust accumulation in summer, autumn and winter, which weaken the performance of solar cells, as well as the shades of trees and tall buildings which affect the efficiency of these cells in the morning and afternoon. This paper aims to evaluate the effect of mud on the performance when one use glass and plastic covers for solar photovoltaic cells . Four different covers were installed on the photovoltaic solar cells, namely polycarbonate (PC), polymethylmethacrylate (PMMA), solar glass and ordinary glass for a study to assess their quality for resistance to mud. Experimental work shows that the drop rate of the maximum power and the drop rate of efficiency are 47%, 60%, 49%, and 46% for PC cover, PMMA cover, solar glass cover, and classic glass cover respectively. Thus it is not recommended to use PMMA coating as mud insulation for solar photovoltaic cells.

Keywords: Glass, Plastic, Covers, Solar Photovoltaic Cells, Mud

1. Introduction

Renewable energy is energy which is generated from natural sources and can be generated again and again as and when required. i.e. sun wind, rain, tides. Worldwide, oil prices will then rise considerably favoring the introduction of various renewable energy sources such as the direct conversion of solar energy (solar cells) ,but also other slake for example, hydroelectric- and wind-power systems. Renewable energy source neither run out nor have any signify can harmful effects on our environment [1, 2]. The economic development and growth by generating the Energy. With the rapid growth of development and the drive to expand the economy, society demands more electricity. Coupled with the realization that unsustainable energy production can have a detrimental effect on our environment [3, 4, 5]. Solar energy is the most prolific method of energy capture in nature. The economic drive to make solar cells more cost effective and efficient has driven developments in many different deposition technologies, including dipping, plating, thick film deposition and thin film deposition [6, 7].

Typically, in order for solar energy to work efficiently and supply energy to a building, a very large amount of space is required, in the form of rooftops or land, in order to install solar panels; these solar panel space requirements are a large impediment to practical usage. This drawback drove researchers to come up with transparent solar cells (TSCs), which solve the problem by turning any sheet of glass into a photovoltaic solar cell.

The previous study shows much the degradation of efficiency for PV solar cell through factors including location, environment, and weather conditions [8-17]. The environment, and weather conditions include rain, cloud, shading from structures such as trees and buildings, dust accumulating on panels, seasonal changes, meteoro-logical impact as snow, and migration routes of animals (birds, etc.) near the production site [18,19]. The contamination of panels caused by these factors affects the out-put voltage of the panel and therefore the energy generation [20].

. This motivates to evaluate the performance for four different covefor which were installed on the photovoltaic solar cells, namely polycarbonate (PC), polymethylmethacrylate (PMMA), solar glass and ordinary glass for a study to assess their quality for resistance to mud. Experimental works concerning these procedures are exhibited in section 2. Section 3 is concerned with findings and discussion while Section 4and 5 are devoted to the conclusion recommendation respectively.

2. Experimental works

The experiment was conducted on solar cells to study the effect of transparent plastic sheets on the efficiency of the solar cell in the presence of mud. The readings were taken several times and efficiency was calculated. This section contains tools and tools used for testing and how to work.

2.1. Experiment Apparatus and Setup

The electrical specifications of the panels used in this study were as follows:

1- Solar cells in sizes (18x9 cm), different surface covers polycarbonate(PC), Polymethyl methacrylate(PMMA), solar glass, plain glass) which was described the physical properties in table 1.
2- 2 Multimeter.
3- Resistant.
4- Light sourcep=50 w.
5- Connecting wires.

2.2. Cover Polymers Surface of PV Solar Cell

Scientists have classified polymers as one of the important classes of materials. They include rubber, plastics, and resins, and in this work, the polymer is used as a cover for solar cells such as:

2.2.1Polycarbonate (PC)

The unpacked polycarbonate showed in Table (1) is a tough, transparent engineering thermoplastic material that offers extremely high impact strength and a high modulus of elasticity. It also has high temperature deflection heat and very little moisture absorption. These properties, along with the good insulating properties of low frequency and high voltage, make polycarbonate a primary material for electrical and electronic components. Its strength, impact resistance, and transparency (unfilled grades only) also make it an ideal material for some transparent structural applications.

2.2.2Properties of Polycarbonate (Pc)

Polymer is derived from the Greek words, poly = many and mers = parts or units with a high molecular mass, each molecule consists of a very large number of single structural units that are joined together in a regular fashion. In other words polymers are giant molecules with a high molecular weight, called large molecules, which accumulate by binding a large number of small molecules called monomers. Polymerizations resulting from the reaction of monomers combine to form a polymer [21]. Polymerization is a chemical reaction in which two or more substances combine together or without anything like water, heat, or any other solvent that develops to form a A high molecular weight molecule. The product is called a polymer and the starting material is called monomer. The physical properties of polycarbonate (PC) as shown in Table No. (1).

Table 1 TYPICAL PROPERTIES Of Polycarbonate (PC)[21]

Property	**Unfilled**	**30% Glass**
PHYSICAL		
Density (lb/in³) (g/cm³)	0.043 1.2	0.052 1.43
Water Absorption, 24 hrs (%)	0.12	0.12
MECHANICAL		
Tensile Strength (psi)	9,500	19,000
Tensile Modulus (psi)	320,000	-
Tensile Elongation at Break (%)	60	10
Flexural Strength (psi)	15,000	23,000
Flexural Modulus (psi)	375,000	1,100,000
Compressive Strength (psi)	12,000	18,000
Compressive Modulus (psi)	240,000	500,000
Hardness, Rockwell	M70 / R118	M92
IZOD Notched Impact (ft-lb/in)	13	2
Tensile Modulus (psi)	320,000	-
Tensile Elongation at Break (%)	60	10
Flexural Strength (psi)	15,000	23,000
Flexural Modulus (psi)	375,000	1,100,000

Hardness, Rockwell	M70 / R118	M92
IZOD Notched Impact (ft-lb/in)	13	2
THERMAL		
Coefficient of Linear Thermal Expansion (x 10-5 in./in./°F)	3.9	1.2
Heat Deflection Temp (°F / °C) at 264 psi	270 / 132	295 / 146
Glass Transition Temp (°F / °C)	293 / 145	300 / 149
Max Operating Temp (°F / °C)	250 / 121	270 / 132
Thermal Conductivity (BTU-in/ft²-hr-°F) (x 10-4 cal/cm-sec-°C)	1.3 6.9	1.3 6.9
Flammability Rating @ less than .45" (11.5mm) thickness @ .45" (11.5mm) thickness and above	H-B V-0	H-B V-0
ELECTRICAL		
Dielectric Strength (V/mil) short time, 1/8" thick	390	470
Dielectric Constant at 60 Hz	3.17	3.35
Dissipation Factor at 60 Hz	0.0009	0.0011
Volume Resistivity (ohm-cm)at 50% RH	1016	1016

2.2.3Acrylic (PMMA)

Acrylics (Polymathic -Methacrylate or PMMA) is an amorphous thermoplastic which is optically transparent, unaffected by moisture, and offers a high strength-to-weight ratio. Common trade names of acrylic include Plexiglas, Lucite , and the physical properties of Acrylics as shown in table (2).

Table 2. TYPICAL PROPERTIES Of ACRYLIC PMMA[21]

Property	**Acrylic**
PHYSICAL	
Density(lb/in³) (g/cm³)	Density(lb/in³) (g/cm³)
WaterAbsorption,24hrs(%)	WaterAbsorption, 24hrs(%)
MECHANICAL	
Tensile Strength(psi)	8,000-11,000
Tensile Modulus(psi)	350,000-500,000
Tensile Elongation at Break(%)	2
Flexural Strength(psi)	12,000-17,000
Flexural Modulus(psi)	350,000-500,000
Compressive Strength(psi)	11,000-19,000
Compressive Modulus(psi)	-
Hardness,	M80-M100
IZOD Notched Impact(ft-lb/in)	0.3
Thermal properties	
Coefficient of Linear Thermal Expansion (x10-5in./in./°F)	5–9
Heat Deflection Temp(°F/°C)at264psi	150-210/65-100
Melting Temp(°F/°C)	265-285/130-140
Max Operating Temp(°F/°C)	150-200/65-93
Thermal Conductivity (BTU-in/ft²-hr-°F) (x10-4cal/cm-sec-°C)	 3.9 1.2
Flammability Rating	-

Property	Acrylic
ELECTRICAL	
Dielectric Strength(V/mil)shorttime,1/8"thick	400
Dielectric Constant at 60Hz	4.0
DissipationFactorat60 Hz	0.05
OPTICAL	
Light Transmission ,minimum(%)	92
Refractive	1.48-1.50

2.3. The Method of Work

Four different covers were installed on the photovoltaic solar cells in Energy Researches Center , Soba, Sudan, namely polycarbonate (PC), polymethylmethacrylate (PMMA), solar glass and ordinary glass. The four different solar cell were exposed to mud and presented to the optical source at 45 angle and was connected to the two metering meters and the two metering devices, one to measure the voltage difference (v) in parallel and the other to measure the electrical current (I) respectively, and the voltage value was zero when the current is V and the current when the resistance is zero (I), and changed the value of the resistance each time and recorded the readings of the difference of voltage and current until the current read the zero and voltages to the maximum value and then draw the voltage and current curve and calculated efficiency and filler equations, repeated the same steps in the case of dust and clay and partial shadow on the cell and calculated Characteristics of Cells are both on their own.

3. Results and Discussion

In this section, the effect of solar cell covers such as ordinary glass cover, PC, PMMA and solar glass on the performance of solar photovoltaic cells, and the resistance of these covers to mud on the performance of solar cells are discussed.

From Fig. 1 to Fig. 4 it can be seen that the open-circuit voltage (V_{0V}) and the short circuit current (I_{SC}) decrease for all the covers of the solar cells exposed to the mud.

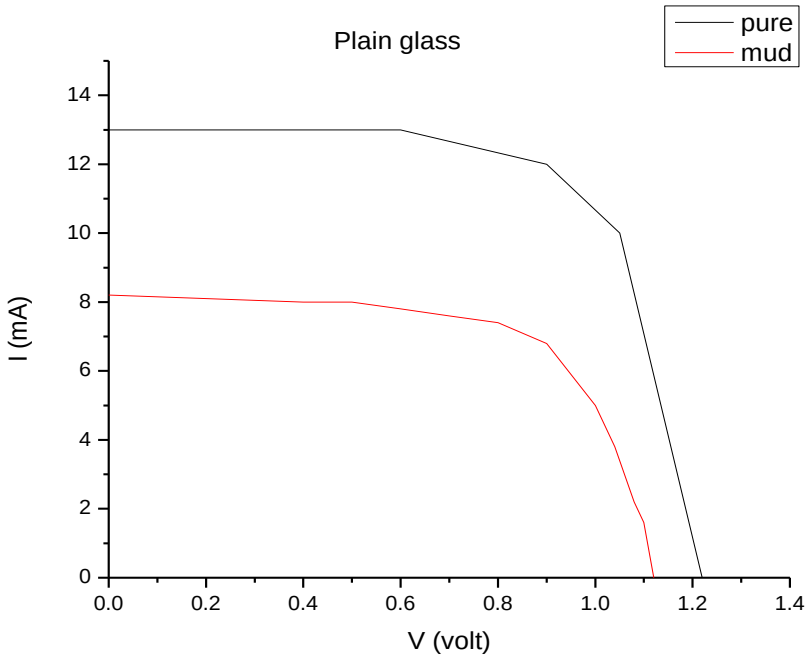

Figure 1: A. I-V characteristics for plain glass Cover

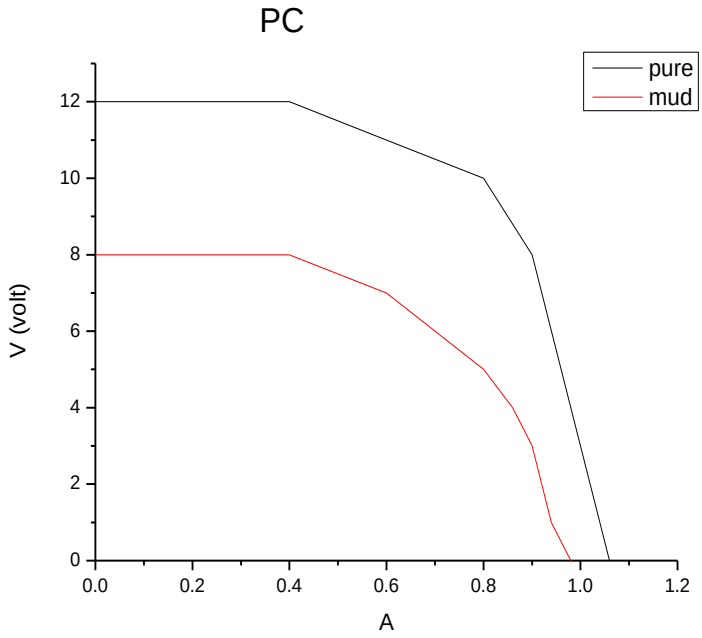

Figure 2: A. I-V characteristics for pure and mud PC

The main reason for the attenuation of low open-circuit voltage (V_{0V}) and short circuit current (I_{SC}) is the attenuation of light transmittance due to mud build-up on the solar PV cover. And because the process of mud accumulation is very easy, it starts first with rain and then accumulates a simple layer of dust until it covers the entire surface, then a second layer is deposited on top of it, and so on [22,23].

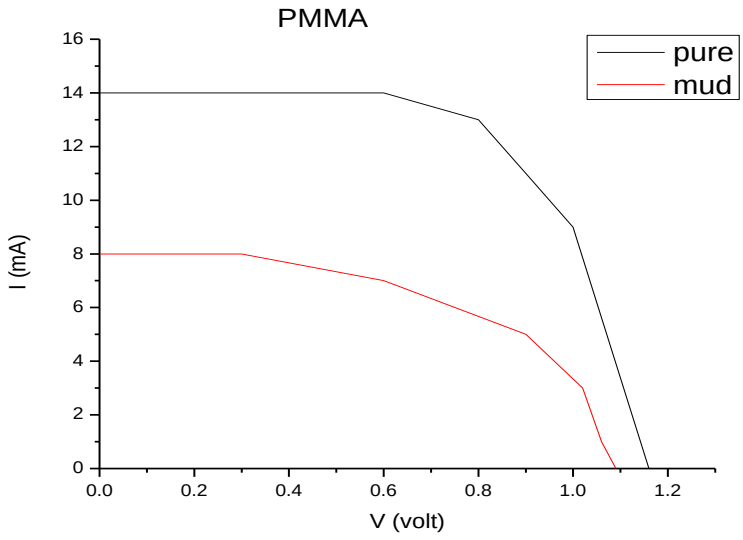

Figure 3: A. I-V characteristics for pure and mud PMMA

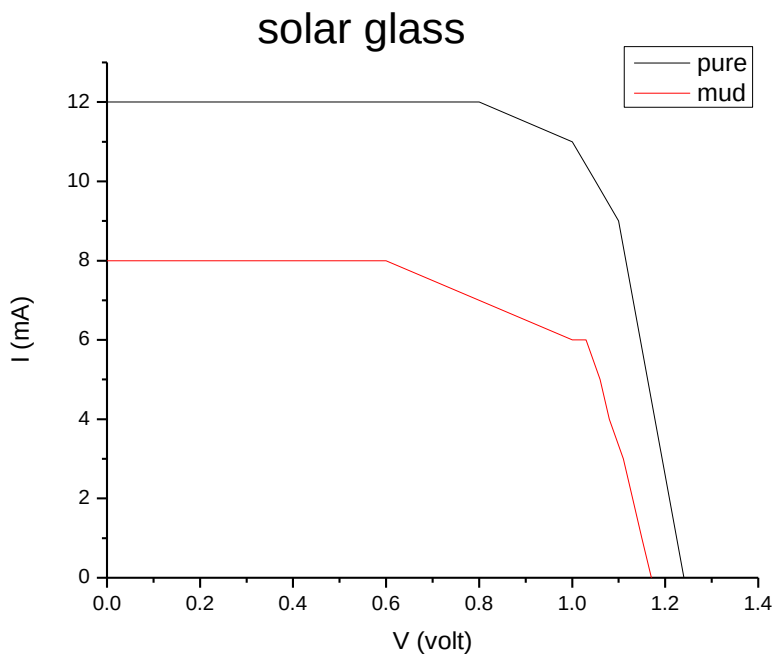

Figure 4: A. I-V characteristics for pure and mud solar glass

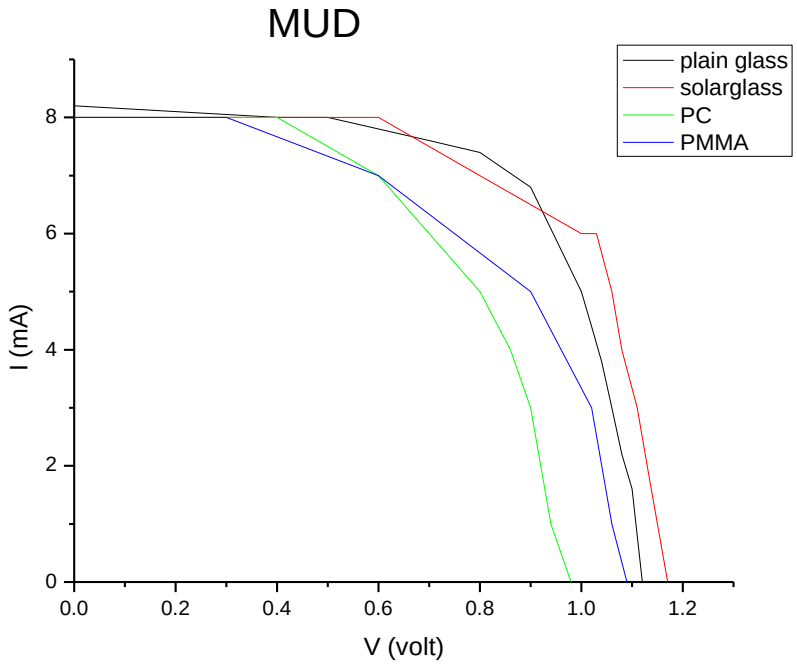

Figure 5: A. I-V characteristics for all solar cell layer mud layer

Various parameters such as maximum power, filling factor and efficiency of different surface photovoltaic cells can respond differently to slurries as shown in Table 6 to Table 7, Fig. 6, 7 and Fig. 5 respectively.

Table 6. The maximum power $_{drop}$ rate for all covers solar cell samples with Mud layer

Cover Sample	**PC**	**PMMA**	**Solar glass**	**Classic glass**
Pure	7.96	10.40	10.97	10.80
Mud	4.21	4.20	5.57	5.92
The maximum power drop rate	47%	60%	49%	46%

Table 7. The Fill Factor drop rate for all cover solar cells samples with Mud layer

Cover Sample	PC	PMMA	Solar glass	Classic glass
Pure	0.623	0.641	0.723	0.678
Mud	0.535	0.482	0.059	0.640
Fill Factor drop rate	14%	25%	**92%**	6%

Table 8. The Efficiency drop rate for all cover solar cell samples with Mud layer

Cover Sample	PC	PMMA	Solar glass	Classic glass
Pure	0.796	1.040	1.097	1.080
Mud	0.421	0.419	0.557	0.587
Efficiency drop rate	47%	60%	49%	46%

From table 6 and table 8 it clears that the maximum power and the efficiency drop rate are 47%, 60%, 49%, and 46% for PC cover, PMMA cover, solar glass cover, and classic glass cover respectively. It is not recommended to use PMMA coating as mud insulation for solar photovoltaic cells.

4. Conclusion

At the end of the research in which the efficiency of solar cells was studied with different types of fiber covers, it was found that the solar cell cover made of polycarbonate resists the shading that occurs due to climate changes from dust, shade and mud if this cover is compared to other covers such as solar glass, plain glass and polymethyl meth acrylates. Hence, the cell efficiency is high when polycarbonate covering is used.

5. Recommendations

The recommendation required to conduct a lot of research related to solar cells because of their importance in our time to take advantage of clean energies (solar energy) by using other methods of modification in the components of solar cells to increase the efficiency of the cell and increase energy to obtain a greater benifit. One recommend the use of a polycarbonate cover with a rough surface to know the effect of the surface on the efficiency of the solar cell. One also needs the use of colored covers and studying the effect of colors on the efficiency of the solar cell.

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