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Research Article

Performance of PEC solar cells depending on different electrolyte variables

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ARTICLE INFO	ABSTRACT

The massive increase in energy demands following the Industrial Revolution has led to a high rate of fossil fuel use. The rate of its formation is far slower than this consumption. However, these fossil fuels are not evenly available, and their excessive consumption produces pollution. Considering all of these factors, the PEC (photoelectrochemical) solar cell presents the possibility of low manufacturing costs in addition to other alluring attributes like efficiency and adaptability. The authors of this study have examined the photovoltaic-photocurrent properties of PEC solar cells based on $MoSe_2$ and WSe_2. The effect of various optical densities and temperature (In the range of 292K-299K) of the electrolyte has been measured on the performance of the PEC solar cell.

Keywords: PEC (photoelectrochemical)

Introduction:

Energy is the crucial currency of the modern era. An indubitable requirement of a growing economy like India, energy is the lifeblood of manufacturing, transport, construction, communication, and mobility. This post-industrial revolution demand for fossil fuels has strained our planet's ecological health. The damage caused by burning the vast quantities of carbon-based fuels needed to run our development engines and modern economies is well known now. The rising demand for power associated with simultaneous growth of urban centers and modernizing rural areas is placing a huge burden on our coal-based energy sector. While current power plants are creaking under the strain, alternative sources like hydropower or wind seem to have limited scope for large-scale power generation in a country where land is tightly contested. Some "renewable" energy modes also come with ease of availability and low cost such as wind mail and solar power generation plants [1,2].

Since the use of energy has become an integral part of our life, the supply of energy should be safe and sustainable. Moreover, it should be economical, environment friendly and socially acceptable. In this context, the present paper is one more step in the development of one of the devices of solar conversion. PEC solar cells are easy to fabricate, convenient and cheap. For the construction of PEC solar cells, Grown $MoSe_2$ and WSe_2 crystals have been used for the present investigation [3].

Experimental Procedure:

Optical density of the electrolyte shows the value of absorbance of light in electrolyte. The optical densities of the different electrolyte solutions for the different wavelengths have been measured by the digital colorimeter (EQUIP-TRONICS, EQ-650-A) at Chemistry Department, R.R. Mehta science college, Palanpur. Different electrolytes of different optical densities have been used in PEC solar cells. The photovoltage- photocurrent characteristics have been measured in each case. The same experiment has been done for the different electrodes.

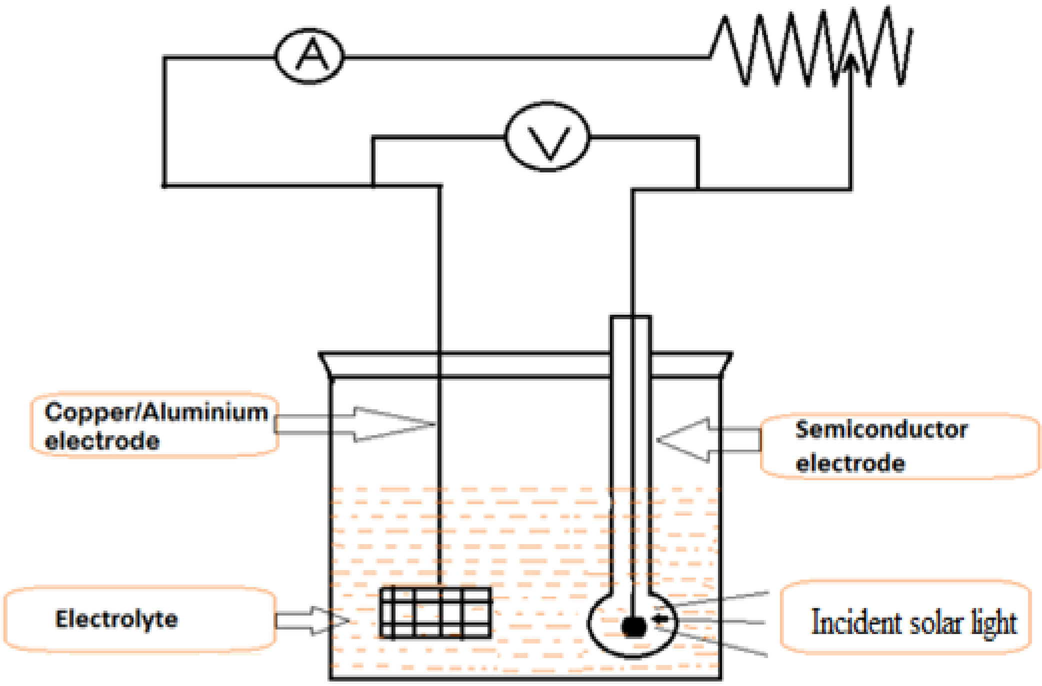

Figure-1. Experimental Set-up

The photovoltage – photocurrent characteristics has been measured by the experimental set-up as shown in Figure-1. The comparison has been prepared to check the effect of optical density of electrolyte on the performance of PEC solar cells. The optical density of electrolyte solution of 0.035 M I_2 + 0.5 M KI + 0.5 M K_2SO_4 & of 0.0175 M I_2 + 0.25 M KI + 0.25 M K_2SO_4 has been measured [7-9]. The data obtained for these electrolytes analyzed and compared.
Moreover, the effect of temperature (in the range of 292K to 299K) on the performance of PEC solar cells has also been observed. The obtained data have been analyzed and compared for the $MoSe_2$ and WSe_2 based photoelectrochemical solar cells.

Results & Discussions:

Optical Density measurements:

In the case of copper, the uneven states of the solar cell could be seen, in which the photoconversion efficiency shows inconsistent manners. The reaction of both the electrodes (Copper and Counter) with the electrolyte solution could be responsible for it. Because of these reactions, the electrodes felt corrosion and the charge flow reduced [17].

Table 1: Photoconversion efficiency and fill factor for the different optical density for $MoSe_2$ based PEC solar cells.

Sr. No.	Electrolyte Solution	Counter electrode	Optical density	Efficiency [η %]	Fill Factor [F.F.]
1	0.035 M I_2 + 0.5 M KI + 0.5 M K_2SO_4	Copper	1.94	1.42	0.131
2	0.0175 M I_2 + 0.25 M KI + 0.25 M K_2SO_4		1.1	0.290	0.357
3	0.035 M I_2 + 0.5 M KI + 0.5 M K_2SO_4	Al	1.94	0.428	0.672
4	0.0175 M I_2 + 0.25 M KI + 0.25 M K_2SO_4		1.1	2.61	0.346
5	0.035 M I_2 + 0.5 M KI + 0.5 M K_2SO_4	Graphite	1.94	0.0007	0.225

6	0.0175 M I_2 + 0.25 M KI + 0.25 M K_2SO_4		1.1	0.0013	0.257

Hence, the produced photocurrent and photo voltage also decreased. This decrease of current and voltage affects the photo conversion efficiency of the solar cell. Figure-2. shows the plot of optical density Vs wavelength. According to this graph, it can be observed that the electrolyte solution of 0.035 M I_2 + 0.5 M KI + 0.5 M K_2SO_4 consists of more absorbance compared to the solution of 0.0175 M I_2 + 0.25 M KI + 0.25 M K_2SO_4. To achieve the higher efficiency, the effect of the optical density of these solutions on the different electrodes has been checked. The results of these experiments have been shown in Table-1 for the copper, aluminium and graphite respectively. In the case of copper, the efficiency increases with the increase in optical density of the electrolyte. The opposite behaviors can be seen in aluminium and graphite compared to the copper electrode. Here, as we increase the optical density of the electrolyte, the efficiency decreases.

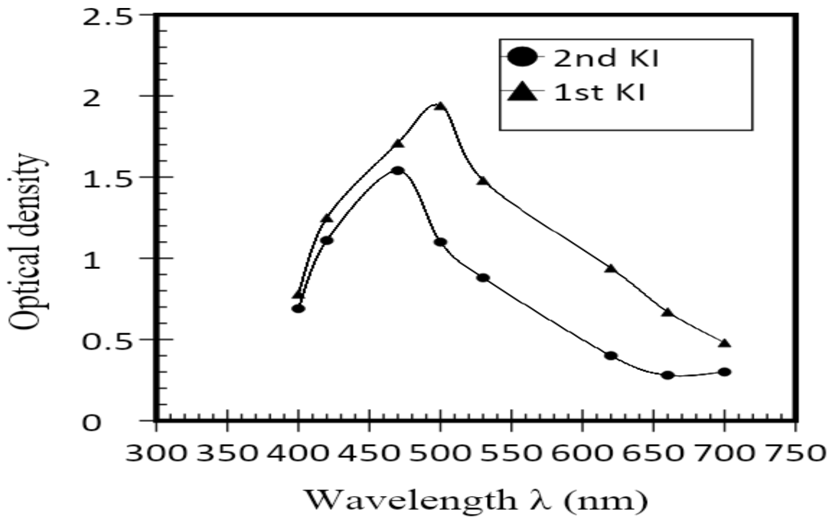

Figure-2. Plot of Optical density Vs Wavelength
[1st KI- 0.035 MI_2 +0.5 M KI +0.5 M K_2SO_4]
[2nd KI-0.0175MI_2 +0.25 M KI + 0.25 M K_2SO_4]

In the case of copper, the efficiency increases with the increase in optical density of the electrolyte. The opposite behavior can be seen in aluminium and graphite compared to the platinum & copper electrode. Here, as we increase the optical density of the electrolyte, the efficiency decreases.
I-V Measurements Regarding Temperature

The effect of temperature on the performance of PEC solar cells has been observed for the operating temperature in the range of 292K to 299K. The photoconversion characteristics have been found for $MoSe_2$ based PEC solar cells using platinum as a counter electrode for the various temperatures in the range as mentioned above. The efficiency has been calculated for each observation.

Table-2. Variation of efficiency with the temperature for $MoSe_2$ based PEC solar cell ($MoSe_2$-Copper-0.035M I_2+ 0.5 M NaI+ 0.5 M Na_2SO_4)

Temperature [°K]	Efficiency [η %]	
	$MoSe_2$	WSe_2
292	1.331	0.51
295	1.061	0.366
297	0.648	0.153
299	0.442	0.142

From Table-2, it can be observed that as we increase the temperature, the photoconversion efficiency of the PEC solar cell based on TMDCs single crystal is decreasing.

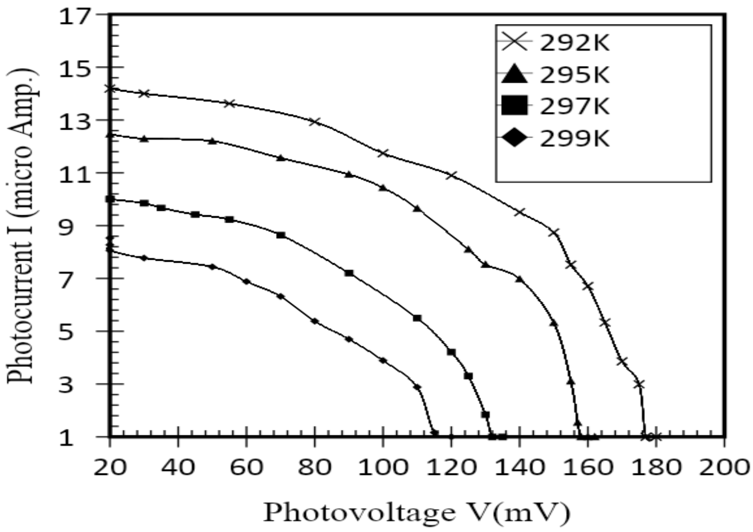

Figure-3. V-I characteristics for different temperatures

From Figure-3, we can say that as the temperature increases, the area of the photovoltage- photocurrent curve decreases and hence photoconversion efficiency decreases. Figure-4 shows the plot of Photoconversion Efficiency Vs Temperature. As we increase the temperature, the band gap of the semiconducting material decreases. The open circuit voltage depends on the band gap. So, the value of open circuit voltage also decreases. So, the efficiency is found to be increasing while reducing the temperature of the electrolyte [14,15].

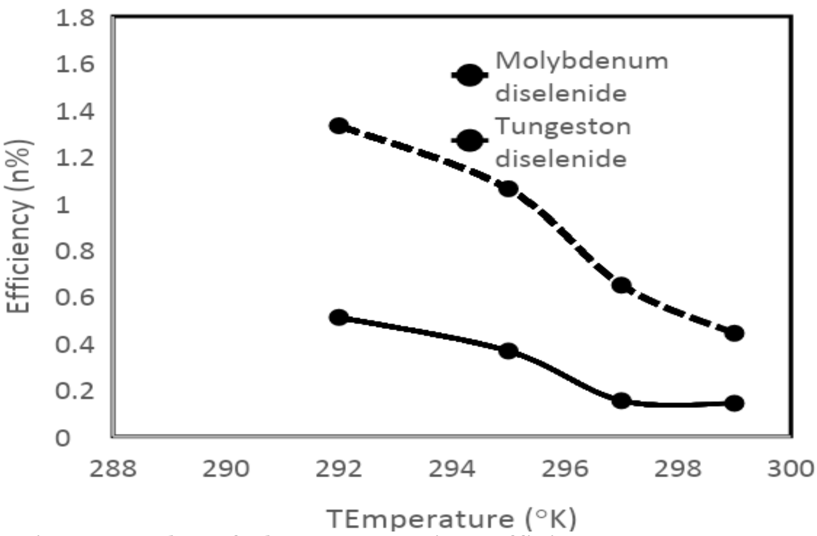

Figure-4. plot of Photoconversion Efficiency Vs Temperature

Conclusion:

1) With the increase in optical density of electrolyte, the efficiency of the PEC solar cell increases; this confirms that ionization and flow of electrons increases in the electrolyte as well as at the interface of the solar cell.
2) From the variation of temperature, the data obtained revealed that, as temperature increases, the efficiency of the cell decreases.

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