

# Photovoltaic Effect in (PbCrO<sub>4</sub>-HgO) Binder Layer

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**Abstract:** *In this paper photovoltaic characteristics of (PbCrO<sub>4</sub>-HgO) binder layer have been reported. The maximum photovoltage has been observed for (75% PbCrO<sub>4</sub>-25% HgO) mixed system. The variations of photocurrent and photovoltage with intensity of illumination, time and wavelength have been observed. The output voltage may be increased by connecting the several cells in series. The photocurrent versus wavelength curves show that the absorption edge of samples may lie in the UV-region.*

**Keywords:** Photovoltage, solar cell, Binder layer, mixed material

## 1. Introduction

Solar energy is the main prerequisite of the life on the Earth. Solar radiation is a direct source for generating heat, cold and power. Indirectly, it is possible to use solar energy through hydropower, wind energy, energy of sea waves, heat energy of environs and energy of biomass [1, 2]. When the photovoltaic cell is illuminated by light energy and light passes through the dielectric, electrons may be raised to conduction band because they are given enough energy to pass across the forbidden energy gap[3]. Thus electrons flow from binder layer to conducting surface of SnO<sub>2</sub> and conventional current flows in the opposite direction.

Thanks to photoelectric effect in semiconductors, we can transform the solar energy in solar cells to power energy. Transformation of solar energy to power energy has wide utilization. Photovoltaic effect which permits to construct photovoltaic (PV) cell, was discovered by A. Becquerel in 1839 [4, 5]. If solar radiation falls on the semiconductor material, the concentration of a charge carrier will rise. Incident photons transfer their energy making electrons and holes excite, which can be used for current conduction. It is necessary that the electric field is made in semiconductor, which will isolate electrons and holes from each other. This kind of field is acquired by PN junction [6]. Equipment that can use this effect is called a photovoltaic (solar) cell. This equipment directly changes solar radiation to direct current (DC)[6]. The solar photovoltaic cell is a semiconductor diode. Generally, solar photovoltaic systems fall into two main groups: • systems are connected to the electricity grid - a "grid connected system" or just "on grid", • systems without connection to the electricity grid - "off grid". In some cases, a combination of both is used forming so-called hybrid or insular system that can supply electricity to the grid or operate completely independently [7]. They are rarely found in the household because of the high investment costs. Regarding the changes in the economic sphere as well as dumping prices, these devices are expected to be widely used in the field of civil engineering [8]. There are many solar cells of single crystals and thin films i.e. CdTe, GaAs and CdS. The photovoltaic cells are also constructed either by silican or by selenium. A larger application of photovoltaic effect is in use of large-area arrays of flat "sun cells" used to recharge batteries of satellite and earth communication equipment. A lot of photovoltaic studies have been made with thin films of several materials[9,10,11]. In this section an attempt has been made

to study the photovoltaic effect in (PbCrO<sub>4</sub>-HgO) thick binder layers.

The main advantage of thin film and binder layer is their promise of low cost. Also, the fabrication of thick binder layers is much easier than the thin films.

## 2. Experimental

The mixed systems of PbCrO<sub>4</sub> and HgO were prepared by heat treatment technique [12]. The photovoltaic cells were fabricated by embedding the sensitive material in polystyrene and sandwiching between the conducting surfaces of two glass plates. The area of the cell was 2.25cm<sup>2</sup> and the thickness varying from 0.041 cm to 0.05 cm. For measurements of photovoltage and current the cell was kept in dark metallic box and illuminated with 300 W Hg-lamp. The intensity over the cell surface was changed by changing the slit width and was measured by luxmeter. The various excitation wavelengths were selected by using the Hg-filter. The photovoltage was measured by digital multimeter and the photocurrent was measured by a nanoammeter. The results are as following:

## 3. Results and Discussions

The five samples of different compositions i.e. 100% PbCrO<sub>4</sub>, (75 % PbCrO<sub>4</sub>-25% HgO), (50% PbCrO<sub>4</sub>-50% HgO), (25% PbCrO<sub>4</sub>-75% HgO) and 100% HgO were prepared by heat treatment technique. The firing temperature and firing time were found to be 400 °C for 40 minutes respectively. The (75% PbCrO<sub>4</sub>-25% HgO) sample shows maximum photovoltage, while maximum photocurrent was shown by 100% PbCrO<sub>4</sub> sample. The 100% HgO sample did not show photovoltaic effect. The effects of various parameters i.e. rise and decay of photocurrent, intensity of illumination and excitation wavelengths have been observed. The photovoltaic studies have also been made by connecting the photovoltaic cells in series and parallel.

### 3.1 Rise and Decay Curves

The rise and decay of current for three different samples has been shown in Figure. 1. The maximum photocurrent is observed for 100% PbCrO<sub>4</sub> sample. A very little amount of photocurrent has been observed by (25% PbCrO<sub>4</sub>-75% HgO) sample. The 100% HgO and (50% PbCrO<sub>4</sub>-50% HgO) samples did not show photovoltaic effect.

When the photovoltaic cell is illuminated by light energy and light passes through the dielectric, electrons may be raised to conduction band because they are given enough energy to pass across the forbidden energy gap. Thus

electrons flow from binder layer to conducting surface of SnO<sub>2</sub> and conventional current flows in the opposite direction.

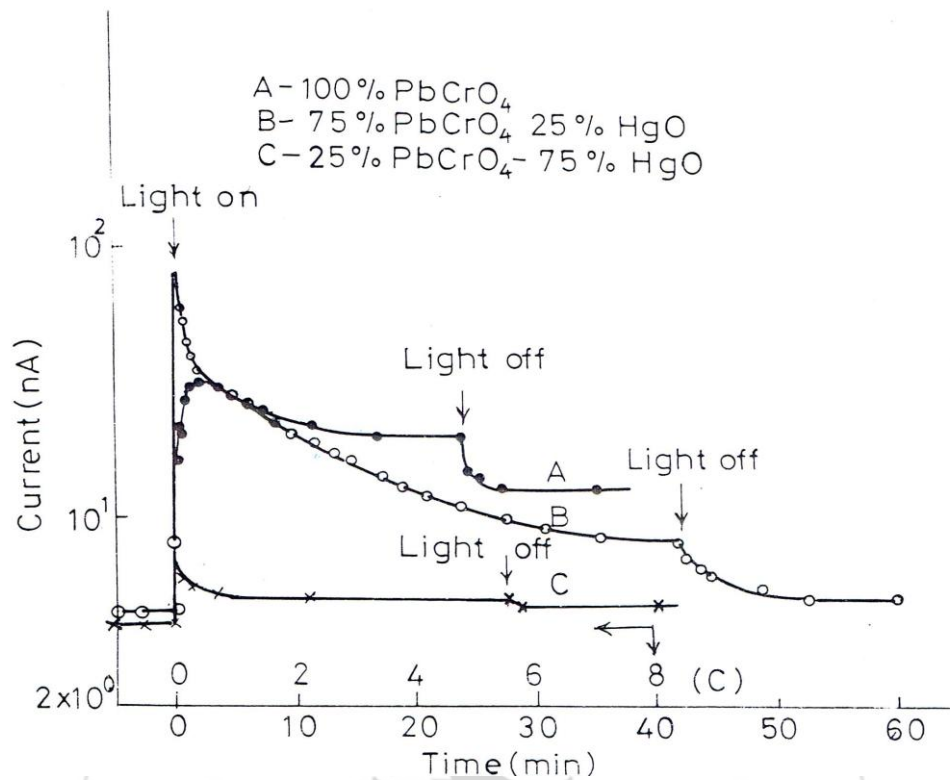


Figure 1: Rise and decay of Photocurrent for different samples (Intensity=6800 lux.Temp=18°C)

From Figure 1 we see that for all the samples the current rises as soon as the light is switched on but after acquiring its maximum value it continues to decay before obtaining its stable value. Decrease in photocurrent with time may be due to rapid recombination of majority carriers with minority carriers. Which are optically freed from imperfection centres. As soon as the light is switched off, photocurrent decreases rapidly.

### 3.2 Intensity of Illumination

Figure 2. shows the variations of photocurrent with intensity of illumination on log-log scale for three different samples. These curves are straight lines having different slopes in different intensity reason[13]. The variation  $I \propto L^\gamma$ , where  $\gamma$  is slope of any straight line section. For 100% PbCrO<sub>4</sub> and (25% PbCrO<sub>4</sub>-75% HgO) samples the value of  $\gamma$  has been found to be less than 1 ( $\gamma < 1$ ). For (75% PbCrO<sub>4</sub>-25% HgO) sample the value of  $\gamma$  is equal to 1.

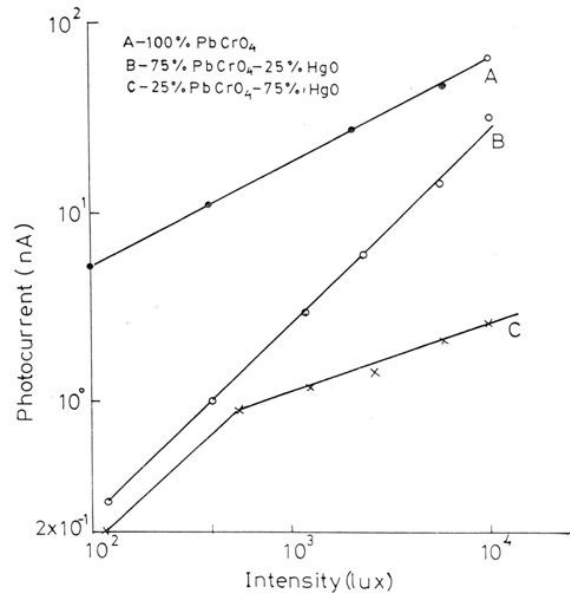
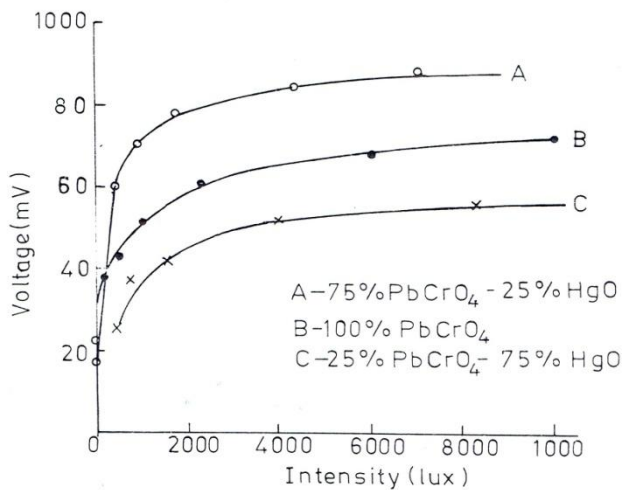
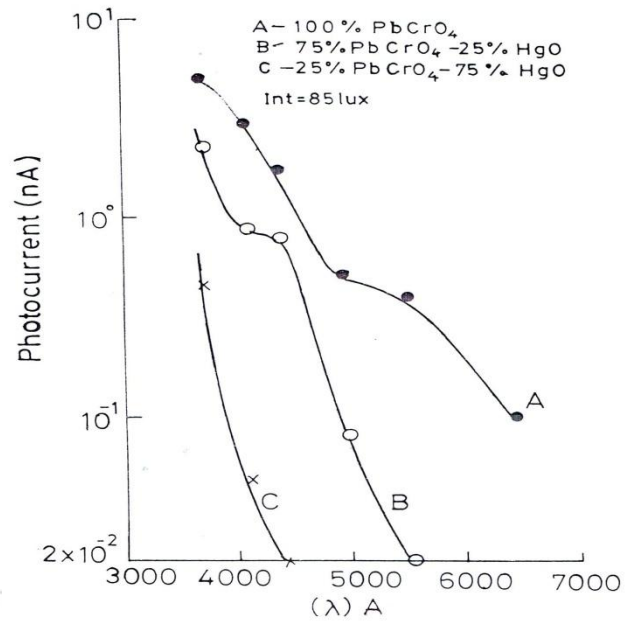


Figure 2: Variation of Photocurrent with light intensities for different samples.

The variation of voltage with intensity of illumination for three different samples has been shown in Figure 3. The maximum photovoltage has been observed for (75% PbCrO<sub>4</sub>-25% HgO) sample. For all the samples the photovoltage initially increases with intensity of illumination then saturates at higher intensity side. The junction between binder layer and the conducting layer of SnO<sub>2</sub>, generates the voltage and current depending upon the illumination. By increasing the intensity of illumination the number of charge carriers raised to conduction band increases, so the photovoltage ( $V_p$ ) and photocurrent ( $I_p$ ) both increase.



**Figure 3:** Variation of voltage with intensity of illumination for (PbCrO<sub>4</sub>) binder layer having different compositions. (Temp=18°C)

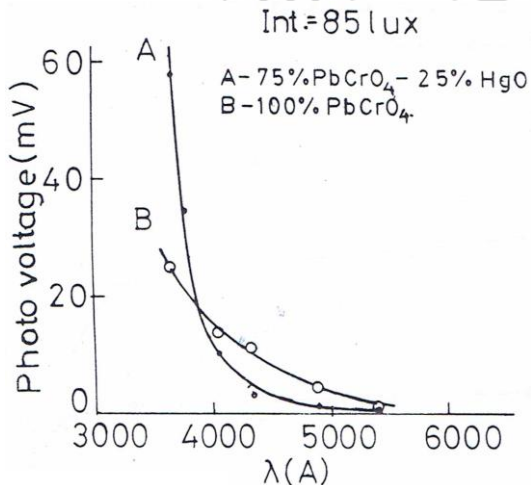


**Figure 4(b):** Variation of Photocurrent with excitation energy for (PbCrO<sub>4</sub>-HgO) binder layer (Temp=18°C)

### 3.3 Excitation Wavelength

The Figure 4(a) shown the variation of photovoltage with excitation wavelength. The observations have been made for two different samples. The variation of photocurrent with excitation wavelength has been shown in Figure 4 (b). The measurements have been made for three different samples.

The variation of  $V_p$  or  $I_p$  with excitation wavelength gives us information about energy gap of the sample. Maximum  $I_p$  and  $V_p$  is obtained in the UV region. So, the band gap of material may lie in the UV region.  $V_p$  and  $I_p$  both decrease with increasing wavelength for all the samples. Because the energy of excitation decreases, which generates little photocarriers.

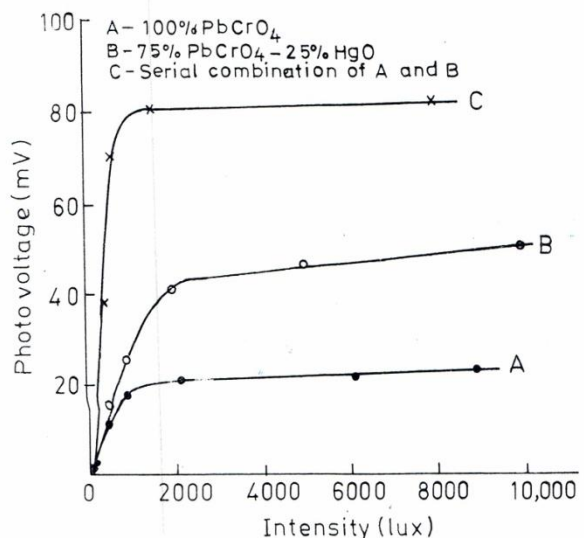


**Figure 4(a):** Variation of  $V_p$  with excitation wavelength (Temp=18°C)

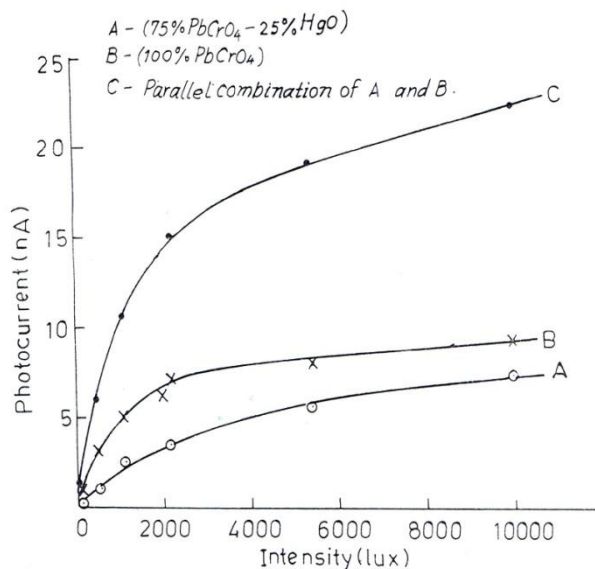
### 3.4 Series and Parallel Combination of Cells

The variation of photovoltage with intensity of illumination for the series combination of two photovoltaic cells has been shown in Figure 5. The curves A and B show variations of  $V_p$  for 100% PbCrO<sub>4</sub> and (75% PbCrO<sub>4</sub>-25% HgO) sample respectively, and curve C shows variation of Photovoltage of series combination of these two photovoltaic cells. It is clear from the figure that the resultant voltage is increased by connecting the two cells in series.

Figure 6 shows the variation of photocurrent with intensity of illumination for parallel combination of two cells i.e. 100% PbCrO<sub>4</sub> (curve B) and (75% PbCrO<sub>4</sub>-25% HgO) (curve A). We observed that by connecting the two cells in parallel, the resultant photocurrent is increased. Because, the total area and the total received light flux is increased.



**Figure 5:** Variation of photovoltage with intensity of illumination for series combination of two cells (Temp=18°C)



**Figure 6:** Variation of  $I_p$  with Light intensity for parallel combination of two cells (Temp=18 °C)

#### 4. Conclusion

When the photovoltaic cells were fabricated by sandwiching the material between Al-plate and conducting glass plate, then no photovoltaic effect has been observed. The output current and voltage may be increased by connecting the several cells in parallel and series respectively. The variation of  $V_p$  or  $I_p$  with excitation wavelength gives us information about energy gap of the sample. Maximum  $I_p$  and  $V_p$  is obtained in the UV region. So, the band gap of material may lie in the UV region.  $V_p$  and  $I_p$  both decrease with increasing wavelength for all the samples.

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