Optical properties of Red pigment for Dye Sensitized Solar Cells

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Abstract: This work contains a description of the optical properties of Lithol Bordeaux dye thin films. The main use of this dye is for Dye Sensitized Solar Cells (DSSCs). Hence the need to deposit this dye as a thin layer in order to know its optical properties. The films were successfully grown by physical vapor deposition (PVD) technique in a high vacuum on transparent (glass) kept at room temperature during the deposition process. Optical properties were investigated by transmittance and photoluminescence measurements. Strong luminescence was observed around 1,68×107 CPS and a reaching an absorbance band about 100 nm in the visible range.

KEYWORDS: Physical Vapor Deposition (PVD), Pigments, Dye Sensitized Solar Cell (DSSC), Transmittance, Photoluminescence.

1. Introduction:

Nowadays, photovoltaic represents an important stake in renewable energies and more generally in energies in general [1] [2]. However, the real challenge for photovoltaic is to significantly reduce the cost [3] per kilowatt-hour produced. Silicon currently offers the best performance, but its purification and treatment lead to very high costs as well as a manufacturing process very toxic to the environment and very expensive. All this is a major obstacle to the development of photovoltaic.

A more original solution is to take inspiration from nature (biomimicry) in the case of photosynthesis of plants. Dye Sensitized Solar Cells (DSSCs) are developed for this purpose. In the future, they could be a reliable solution with low cost and equivalent or better performance.

As its name suggests, the dye is the key element of the cell that behaves like a kind of artificial chlorophyll, converting the absorbed solar radiation into electricity by a process very different from the usual photovoltaic cells made of silicon.

Unlike the production of silicon photovoltaic panels, the production of Grätzel cells requires neither much energy nor delicate operations [5] [6].
The DSSCs are made of a dye/liquid solvent mixture trapped between two transparent electrodes, which makes it possible to make transparent panels of various colors according to the dye chosen [7] [8] [9].

For our study, we will rely on a red dye under the industrial name Lithol Bordeaux and the chemical formula is C$_{21}$H$_{12}$N$_{2}$O$_{6}$SCa which is recommended normally for coating and interior painting. So the purpose of this work is to enhance its use as a coating and paint pigment and apply it to DSSCs. In this paper, we will present the finding of the optical properties of the red dye via transmission and photoluminescence deposited by Physical Vapor Deposition (PVD) technique [10].

2. Technique of deposition:

Lithol Bordeaux dye was deposited as a thin film on glass substrates by means of Physical Vapor Deposition (PVD) technique [11] [12] using equipment shown on Figure 1. Cleaning substrates are important in the results of the optical properties. So the procedure of cleaning is as follows: acetone bath in ultrasonic followed by the ethanol for 15 min each. After that, cleaned by the isopropanol using the flow synthesis [13] [14].

The technique of evaporation was performed by the heat of the material by a tungsten resistance coil in a vacuum chamber under pressure of about $2 \times 10^{-5}$ Tr. Once the evaporation is done, the thin film is created.

Figure 1: PVD apparatus. Left part – evaporation equipment: S – source (effusion cell and heater), SH – sample (substrate) holder, TC – K-type thermocouple, PS – power supply. Right part – scheme of vacuum system: VC – vacuum chamber, V1-4 – manual valves, B – b baffle, G1-2 – vacuum gauges, VC – equalization vacuum chamber, RP – sliding vane rotary vacuum pump, DP – diffusion pump.

3. Transmittance:

The transmittance ($\lambda$) of the film was measured at normal incidence in the spectral range 190–1100 nm using a double-beam spectrophotometer (Perkin Elmer Lambda 2Spectrophotometer). The spectral distribution of the transmittance for the red dye thin film is shown in Figure 2.

Figure 2 shows that in the visible range the material absorbs the light. Nevertheless, from 490 nm the transmittance increases and after reaches 0.6 in the infrared. In brief, we can say that it absorbs in visible range.
4. Photoluminescence:

Photoluminescence was investigated by the FluoroMax 4P apparatus and the excitation source is a xenon lamp. For our material, we excited with 480 nm. As shown in Figure 3, the intensity luminescence is strong and reaches exactly $1,67754 \times 10^7$ CPS at the emission wavelength 587 nm. It is interesting to not have only one maximum emission wavelength but to have a broad emission in the maximum intensity. It means, that if we exit with 480 nm as in our case, the material will shin and emit in many emission wavelengths for 10 nm and from 584 nm to 593 nm.

Thus, Figure 4 shows the 3D excitation-emission fluorescence spectrum [15] and exhibits three maximum intensity of $1.68 \times 10^7$ CPS corresponding to 355(396)(478) nm / 587 nm. This means that not only 480 nm can excite our material, but also it excites with 355 nm and 396 nm for getting the maximum intensity photoluminescence.
4.

Figure 4: 3D excitation-emission fluorescence spectrum of the red dye

5. Conclusion:

The present study was designed to determine the optical properties of Lithol Bordeaux dye thin films. The Physical Vapor Deposition (PVD) was adopted as a technique of deposition in a glass substrate where we obtained a very homogeneous thin layer. This work then go to the optical characterization by transmission and it reaches 60% and also investigated by photoluminescence. The results of this investigation show a strong luminescence from 584 nm to 593 nm in the average of 1.665×10^7 CPS, and a second major finding was in 3D excitation-emission fluorescence spectrum which presents a three maximum intensity corresponding to the same emission wavelength but in three different excitation wavelength. In conclusion, since our material is shiny and presents strong luminescence with only a small slit of the measurement about 2 nm, and also absorbs in the visible range, it is encouraging to apply this dye in solar cells.

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