



# Photo-stability of the photons converter applied in the photovoltaic conversion systems

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## Abstract

In this work we develop the idea of using a poly methyl methacrylate (PMMA) polymer doped with optically active molecules such as photovoltaic encapsulation materials. The effect of this encapsulation system on the incident solar spectrum has been obtained from direct allowed transition after the samples have been exposed to sunlight. A resulting, the incident solar spectrum at the interface is red-shifted for a better fit with the spectral response of SiO<sub>2</sub>/Si solar cell structures. The simulation results showed that the short-circuit current density increased by 7%. Therefore the mechanism of the photo-degrading by UV illumination of an LDS has been studied to identify molecular changes that occur in the organic dye when exposed to UV light. The photo-degrading effect of the PMMA layer was measured by CONICA-MINOLTA spectrometer, as a function of increasing exposure time to UV light. The UV Photo-degrading studies revealed that the more photo-stable dye doped in value.

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## 1. Introduction

The major problem with solar energy technology is to reduce the cost of conversion of this energy or how to improve the efficiency of solar cells (Rothmund, 2014; Griffini et al., 2013). The use of luminescent layers as a photon converter (LDS) is among the most effective methods to improve the performance of photovoltaic solar cells and reducing the cost of photovoltaic conversion (Klampafitis et al., 2009; Richards and McIntosh, 2006; Bailey et al., 2007). The LDS layers typically consist of a host material (often a polymer) doped with appropriate

luminescent species. The LDS sheet is designed to absorb high-energy photons not converted and re-emit them at a higher wavelength (low energy) where the solar cell to better performance (Ross et al., 2012; Alonso-Álvarez et al., 2011; Ross et al., 2013; Carbone et al., 2011).

Due to the nature of operation of the conversion of solar energy systems are subject to a set of constraints on exposure to environmental conditions, and these processes have detrimental effects on the performance and the duration of life of the system long term (Kurian et al., 2002; Ceaykara and Gueven, 1999). These stresses include UV radiation, temperature, atmospheric gases and other pollutants. In addition, rain, dust, wind, etc., may impose additional losses in the performance of a solar system. In this work, the mechanism of the photo-degradation by UV illumina-

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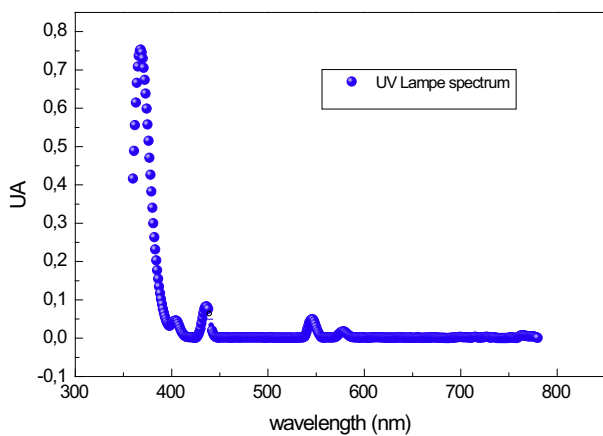
tion of an LDS has been studied to identify molecular changes that occur in the organic dye when exposed to UV light. The photo-degradation of the PMMA layer was monitored using the CONICA-MINOLTA spectrometer, using increasing exposure time to UV light. In addition, a correlation was found between the dye molecule photo-degradation and the electrical parameters of the solar cell structure LDS/SiO<sub>2</sub>/c-Si.

## 2. Experimental setup

The PMMA samples doped with fluorescent dyes, as a fluorescent solar collector, were prepared by a radical polymerization method (McIntosh and Richards, 2006; Maabong et al., 2015). A samples shift the blue and UV wavelengths of photons to the Vis-IR region. The shifting phenomena are observed on a solar spectrum AM 1.5 G in the region of Bou-Ismaïl (Alt: 55 m, Latitude: 36.64°, Long: 2.69°) by the CONICA-MINOLTA spectrometer instrument. All samples were irradiated with artificial UV light (2.4 W/m<sup>2</sup> density, 220–400 nm spectrum range Fig. 1) in the ambient conditions for a two day period, the photo-degradation effect of PMMA doped layers was



(a)



(b)

measured using the CONICA-MINOLTA spectrometer in the spectral range from 360 to 780 nm, in an increase in the duration of exposure to UV light.

## 3. Results and discussion

The LDS film's effect on the incident solar spectrum in the 360–780 nm region is shown in Fig. 2. Identify two different absorption peaks may be observed. The shorter wavelength absorption peaks 445–475 nm is attributed to the absorption of the lateral substituent's of the dyes molecules, while the longer-wavelength absorption peak 576 nm is associated with the absorption of the core of the dyes molecules. Furthermore the fluorescence emission spectrum of LDS films has introduce a notable change on the incident solar spectrum in the visible region 600–756 nm attributed to the dyes cores.

In order to measure the evolution of the effect of LDS films during UV light exposure, as observed on AM 1.5 G solar spectrums after transmitted LDS systems, were collected at increasing UV irradiation times (Fig. 3). The different spectra will be as inputs for simulation models of the solar cells.

Assuming that a solar cell structure SiO<sub>2</sub>/c-Si is exposed to the incident solar spectrum, Fig. 4, it is possible to simulate the parameters of the latter (McIntosh and Richards, 2006). The curve  $J(V)$  is the real identity of the solar cell component, it includes the essential characteristics of the solar cell ( $J_{sc}$ : the short-circuit photocurrent density,  $V_{oc}$ : open circuit voltage,  $P_{max}$ : the maximum power point), two other important parameters, FF fill factor and conversion efficiency  $\eta$  (McIntosh and Richards, 2006).

Both Figs. 5 and 6 shows a set characteristics  $J(V)$  and  $P(V)$  of the two structures studied (with and without PMMA doped), they show an increase in the density of the photocurrent (7%) for the first structure.

The efficiency gain  $\Delta\eta$  resulting from the incorporation of an LDS film to a solar cell was evaluated. This gain is caused by an increase in solar cell current density and can be calculated as follows:

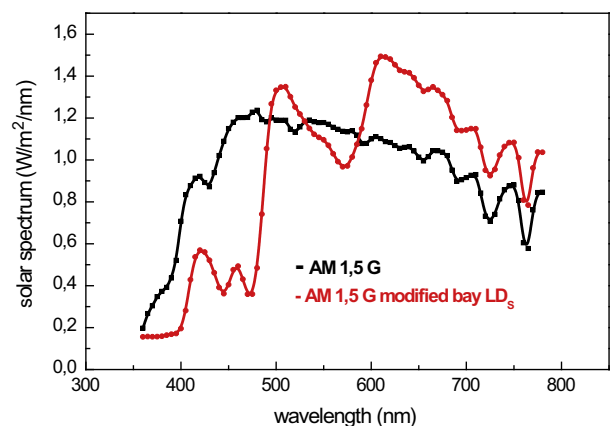


Fig. 2. The experimental data effect of the LDS system down-shifting on the AM 1.5 G solar spectrum.

Fig. 1. (a) Test stand photo-degradation by exposure to UV-light. (b) Artificial UV lampe spectrum.

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