



**Luminescent solar concentrators employing new
Eu(TTA)₃phen-containing parylene films**

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Luminescent solar concentrators employing new $\text{Eu}(\text{TTA})_3\text{phen}$ -containing parylene films

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Abstract

New robust luminescent solar concentrators were produced by growing $\text{Eu}(\text{TTA})_3\text{phen}$ -containing parylene thin films on PMMA slabs through a novel co-deposition process. As it is the first time that $\text{Eu}(\text{TTA})_3\text{phen}$ molecules were inserted in parylene matrix, the deposition process was investigated and the features of the samples were extensively analyzed. FT-IR analysis demonstrated the integrity of the vacuum sublimated $\text{Eu}(\text{TTA})_3\text{phen}$ molecules. AFM analysis showed the very flat surface of the films ($R_q=3.7$ nm) which is strategic in LSCs for minimizing the light scattering at the air/film interface. The optical measurements demonstrated that $\text{Eu}(\text{TTA})_3\text{phen}$ -containing parylene exhibits higher absorption than the conventional $\text{Eu}(\text{TTA})_3\text{phen}$ films and the luminescence peaks characteristic of $\text{Eu}(\text{TTA})_3\text{phen}$ compound. This indicates that the Eu complex is not affected by the matrix interaction thus maintaining its extremely large Stokes shift. Moreover the parylene matrix improves the luminescence intensity of the films: in fact, under the same absorption these films show a luminescence intensity more than two times higher than standard $\text{Eu}(\text{TTA})_3\text{phen}$ ones. The current-voltage (I-V) measurements show that the $\text{Eu}(\text{TTA})_3\text{phen}$ -containing parylene LSCs produce a current density more than twice as high as conventional $\text{Eu}(\text{TTA})_3\text{phen}$ ones with the same $\text{Eu}(\text{TTA})_3\text{phen}$ quantity and that their efficiency decreases more than ten times slower than organic-based LSCs at increasing illuminating area, thus highlighting the feasibility of developing large size LSCs.

Keywords: Luminescent solar concentrators, Luminescence, Thin solid films, Europium, Parylene

1.Introduction

Luminescent solar concentrators (LSCs) consist of peculiar luminescent slabs: solar light incident on an LSC is absorbed by dyes, re-emitted into a guided mode in the slab, and finally collected by photovoltaic (PV) cells mounted at the edge of the slab ^{1,2}. This way LSCs concentrate the light on small high-efficiency solar cells where geometric concentration is given by the ratio of the exposed surface to the area of PV cells ³. LSCs present several advantages in comparison to the traditional optical solar concentrators such as: i) LSCs accept both direct and diffuse light; ii) are static and do not need voluminous and expensive solar trackers; iii) prevent the solar cells from overheating; iv) present a largely improved architectural integration.

LSCs are generally composed by PMMA and PC ⁴ polymer sheets in which luminescent dyes are dispersed. Recently different geometries have been tested in order to improve the performances and the versatility of LSCs: at this purpose thin film devices obtained by coupling luminescent films with transparent waveguides have been proposed ^{5,6}. Despite of the appealing concept, up to now two pressing drawbacks have slackened the affirmation of LSCs as commercial devices: the self-absorption of the fluorescence and the scarce photo-stability of the organic dyes.

In this work new luminescent thin films based on rare earth complex dispersed in a highly stable matrix have been developed as a new prospective in the field of LSCs. For the first time we inserted Eu(TTA)₃phen compound in a host polyxylylene matrix by means of a novel physical vapour co-sublimation process. The chemical structure of Eu(TTA)₃phen is reported in Figure 1: it is composed by an organic part and Eu³⁺ ion, which are responsible for the absorption and the emission processes, respectively. The energy transfer mechanism occurring between organic ligands and central ion confers to this compound a long Stokes shift value which results in zero self-absorption losses. Polyxylylene polymers, widely known as Parylene, were used as dye-hosting matrix owing to their transparency and barrier properties. In fact, thanks to the peculiar solvent-free deposition process based on the vapor phase pyrolysis of paracyclophane⁷, parylene can be deposited as uniform, conformal and pin-hole free films providing an excellent barrier to both liquids and gases ⁸. Owing to these outstanding properties, parylene films have been used for improving the stability of several typologies of devices such as organic diodes ⁹, electronic boards and LEDs ^{10,11}, and organic solar cells ¹². As the optical properties of the common organic dyes are jeopardized by the simultaneous effect of UVB and oxygen interaction, their dispersion into a hosting parylene matrix represents a novel really promising solution for the development of novel luminescent materials. Nevertheless, in spite of their peculiar properties, parylene polymers have been rarely used as dye-host matrices owing to the peculiar characteristics of their deposition process which renders challenging the coupling of a suitable process for incorporating guest

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3 functional molecules. In this work $\text{Eu}(\text{TTA})_3\text{phen}$ molecules are directly co-sublimated with
4 parylene in the polymerization chamber. This novel technique has recently demonstrated to strongly
5 improve the robustness of dye-based LSCs without affecting their optical properties and decreasing
6 their performances¹³. After verifying the feasibility to sublimate $\text{Eu}(\text{TTA})_3\text{phen}$ compound in a
7 coarse vacuum, differently thick $\text{Eu}(\text{TTA})_3\text{phen}$ -containing parylene samples were produced in
8 order to study the influence of the thickness on the final performances of the LSCs. The physical
9 features of the samples were accurately analyzed by AFM microscopy, FT-IR, and optical analyses.
10 The performances of LSC devices were tested by coupling a silicon cell to one edge of the PMMA
11 waveguide and measuring the current-voltage (I-V) curves under standard solar radiation (AM
12 1.5G). (I-V) measurements with different radiation area were eventually analyzed for investigating
13 the feasibility to develop large size LSC devices.
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2.Experimental

2.1 Preparation of the samples

The molecular structures of parylene C and of the complex tris(2-thenoyl trifluoroacetone) mono (1,10-phenantroline) Europium (III) ($\text{Eu}(\text{TTA})_3\text{phen}$) are reported in Figure 1. $\text{Eu}(\text{TTA})_3\text{phen}$ was synthesized according to a previously reported literature procedure¹⁴. Di-chloro-di-p-xylylene (parylene C dimer) was provided from PPS (Germany) at >99% purity.

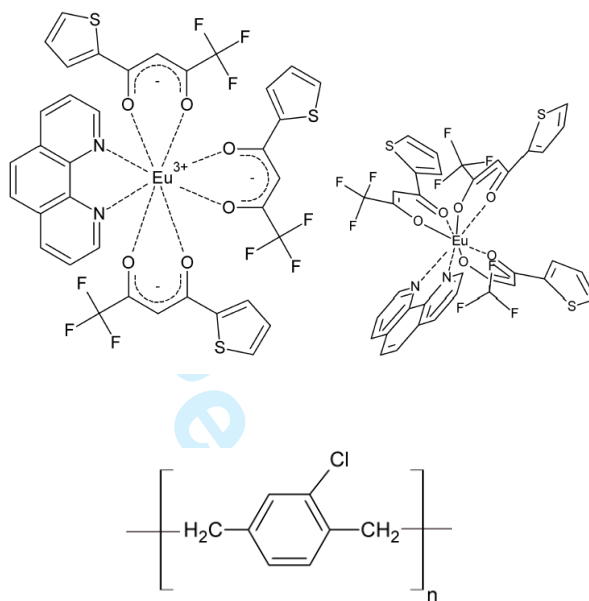


Figure 1. Chemical structure of $\text{Eu}(\text{TTA})_3\text{phen}$ (top) and parylene C (bottom)

The plant used for the deposition of $\text{Eu}(\text{TTA})_3\text{phen}$ -containing parylene films is a Labcoater LC300 (PPS) appositely customized for the co-deposition of parylene monomer and $\text{Eu}(\text{TTA})_3\text{phen}$ dye. The deposition processes were conducted at a pressure of 3 Pa using fixed amounts of parylene C dimer (2.5 g) and $\text{Eu}(\text{TTA})_3\text{phen}$ powder (70 mg).

The films were grown on different substrates: lapped P-doped (100) silicon wafers (Bayville Chemical Co.) for FT-IR, AFM and fluorescence measurements, 400 μm thick corning microsheet glass slides with a refractive index of 1.523 for optical absorption, and 50 x 50 x 5 mm^3 PMMA slides for testing as LSC devices.

The substrates were placed on a rotating sample holder for increasing the uniformity of the dye dispersion. The deposition rate and film thickness were measured during the deposition process by a quartz crystal microbalance placed close to the sample holder.

2.2 Characterization of the samples

FT-IR spectra were recorded with a resolution of 4 cm^{-1} using a Jasco FTIR 660 Plus spectrometer. The sample cell and the interferometer were evacuated for removing the signals of water and atmospheric gases. The surface morphology of the samples was investigated in air by a no-contact-mode atomic force microscope (AFM) model C-21 (Danish Micro Engineering), mounting a DualScope Probe Scanner 95-50. In agreement with previous works^{15,16}, AFM was also used to measure the thickness of the samples. UV-visible absorption spectra were performed with a resolution of 1 nm using a Jasco V-570 dual-beam spectrophotometer. Emission spectra were recorded with a spectral band width of 1 nm through a Jasco FP6300 spectrofluorometer in front-face geometry by collecting the fluorescence light from the surface hit by the excitation beam. The acquired data were corrected by considering the spectral response of the detection system. LSC performances were measured using a 300 W solar simulator (Lot-Oriel) with an AM 1.5 radiation. The uncoated bottom face and three lateral faces were put in contact with blackened surfaces while the fourth lateral face was coupled to a 50*5 mm silicon cell by means of an optical silicone oil grease.

3. Result and discussion

3.1 Film deposition

In agreement with the parameters of parylene matrix deposition, the co-sublimation of Eu complex was conducted at $P = 3\text{ Pa}$. The deposition rate of $\text{Eu}(\text{TTA})_3\text{phen}$ was calibrated in order to analyze the feasibility of the evaporation process and find the deposition parameters. Table 1 shows the $\text{Eu}(\text{TTA})_3\text{Phen}$ deposition rates, expressed as the number of moles deposited per surface and time units, as a function of the crucible temperature.

Temperature (°C)	Deposition rate ($10^{-13}\text{ moles cm}^{-2}\text{ s}^{-1}$)
172	6.7
173	8.0
174	11.6
175	17
176	25.3
177	32.8
178	38.9

Table 1. Deposition rate of $\text{Eu}(\text{TTA})_3\text{phen}$ at $P = 3\text{ Pa}$.

The data demonstrated that Eu(TTA)₃phen compound can be sublimated in coarse vacuum and that the deposition rate is strongly influenced by the crucible temperature increasing more than 2.5 times when temperature increases from 172°C to 178 °C. The deposition rate as a function of the crucible temperature can be fit by the following function^{17,18}:

$$\text{Log } D = A - \frac{B}{T}$$

where D is the deposition rate expressed in moles cm⁻² s⁻¹, T is the absolute temperature expressed in K and A and B are constants determined by the fits and value respectively 18 and 1.3 *10⁴ K.

The comparison with literature data finally highlights that Eu(TTA)₃phen compound sublimates at temperatures significantly lower than commercial dyes: for example Lumogen Red (LR305) compound in coarse vacuum sublimates at 270 °C¹³. Moreover the accurate calibration of the Eu(TTA)₃phen deposition rate increase with the crucible temperature allows to perform highly controlled growing process.

In order to establish a precise and reproducible co-sublimation process, the deposition rate of parylene was also measured and an average mass deposition rate of 56.5 ng /s * cm² (±5%) was found. This value corresponds to a molar deposition rate, obtained by assuming the Parylene C monomer (M.W.=138.62) as elementary unit, of 4.1x10⁻¹⁰ moles/s * cm².

After defining the deposition parameters (P = 3 Pa, T = 178°C), several Eu complex - containing parylene films were produced by co-sublimating Eu complex and parylene C dimer. Five differently thick films were obtained by multiple deposition runs. Table 2 reports the nomenclature, the deposition parameters, and the main parameters of the samples produced in this work.

Sample	Eu	Pary	S320	S640	S960	S1280	S1600
Thickness (nm)			322	646	964	1288	1612
Eu(TTA) ₃ phen surface concentration (mg cm ⁻²)		0	0.045	0.089	0.134	0.179	0.224
Position of main absorption peak (nm)	347	290	290 347	290 347	290 347	290 347	290 347
Absorbance at 347 nm	0.155	0.084	1.326	2.848	saturated	saturated	saturated
Position of main emission peak (nm)	613	360 380	613	613	613	613	613
Roughness Rq (nm)		3.5	3.7			3.6	

Table 2. Nomenclature and principal features of the films produced in this work

The co-sublimation process allows to conduct well controlled and reproducible growing processes and places itself as a novel promising technique for producing high efficiency luminescent films. In

particular, the knowledge of deposition rates of host and guest components allows to accurately control the growing rate, the thickness, and the dye concentration of the films.

As it was the first time that $\text{Eu}(\text{TTA})_3\text{phen}$ -containing parylene films were produced, their properties were widely investigated. The chemical properties of the films were assessed through FT-IR analysis (see Figure 2).

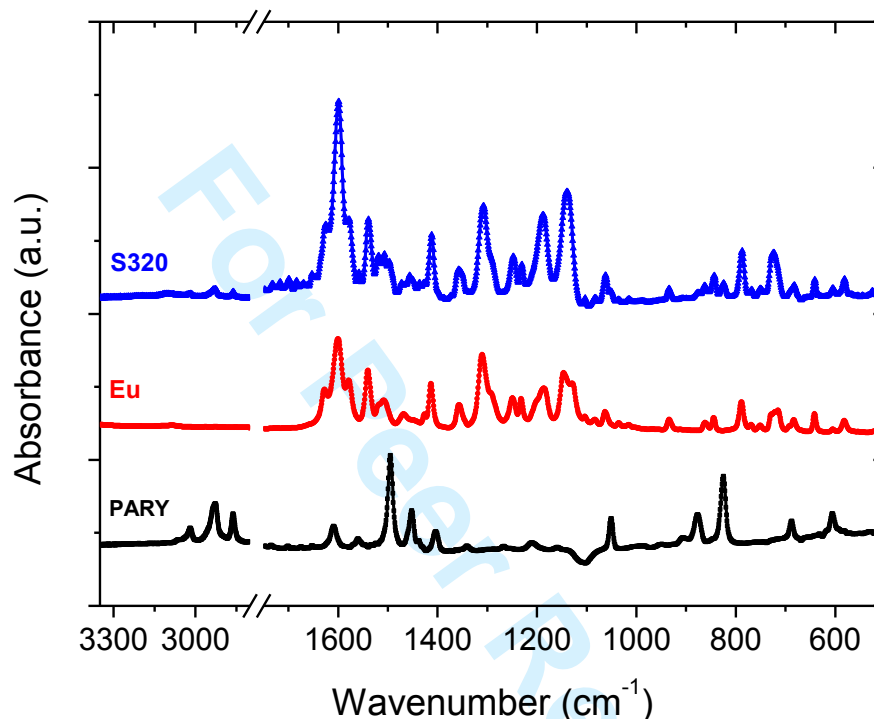
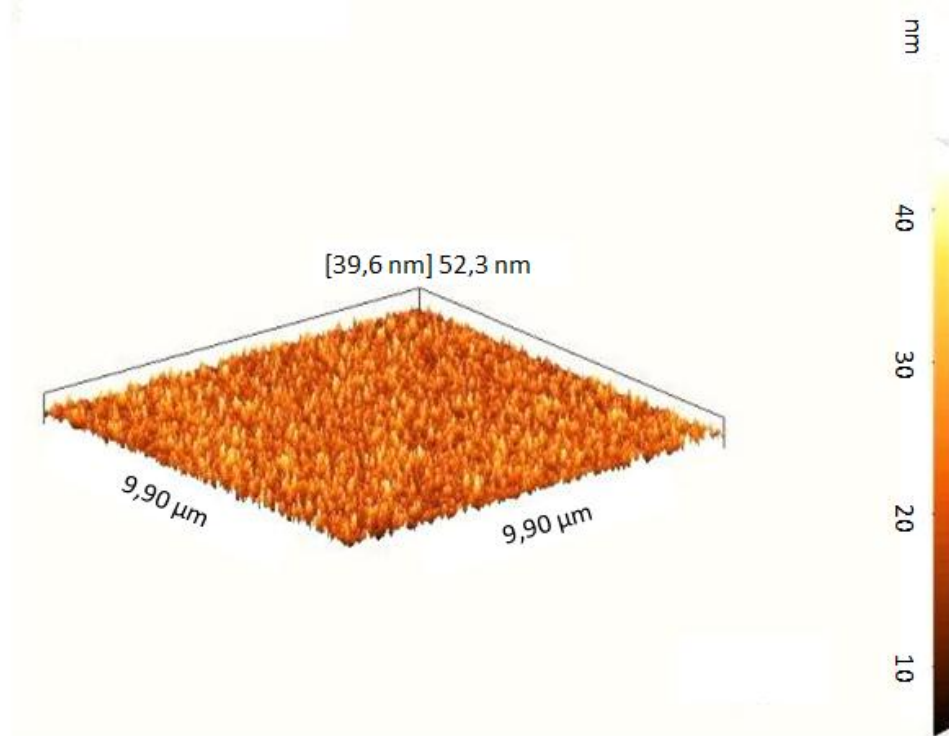


Figure 2. FT-IR spectra of parylene film (PARY), $\text{Eu}(\text{TTA})_3\text{phen}$ vacuum evaporated film (Eu), and $\text{Eu}(\text{TTA})_3\text{phen}$ -containing parylene film S320.

The parylene matrix is responsible of the peaks at 2860 and 2925 cm^{-1} , due to symmetric and anti-symmetric stretching vibrations of sp^3 and sp^2 C–H bonds, and of the peak at 3019 cm^{-1} due to the C–H stretching modes of aromatic hydrocarbons. The integrity of the $\text{Eu}(\text{TTA})_3\text{phen}$ molecules within the sample is confirmed by the presence of all the characteristic peaks of $\text{Eu}(\text{TTA})_3\text{phen}$ ¹⁹. In fact, the good coordination of Eu ion to the ligands via the C=O (TTA) and N atoms (phen) is demonstrated by the peaks at 1625 and 1600 cm^{-1} (C=O stretching vibrations), at 1539 cm^{-1} (C=N phenantroline stretching vibrations), at 845 (C–C phenantroline ring vibrations), and at 725 cm^{-1} (C–H phenantroline bending vibrations)²⁰. The integrity of the sublimated $\text{Eu}(\text{TTA})_3\text{phen}$ molecules is confirmed by the optical emission spectrum of the vacuum evaporated film which shows the characteristic peaks of the pristine compound (see Figure 4).

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3 The surface roughness of the samples was investigated by AFM microscopy. Figure 3, which
4 shows the AFM image of sample S1600, highlights that the $\text{Eu}(\text{TTA})_3\text{phen}$ -containing parylene
5 films are characterized by low roughness ($R_a=3.8$ nm; $R_q = 3.7$ nm). The surface flatness, which
6 permits to minimize the light scattering at the air/film interface, represents a strategic feature for
7 developing efficient LSC devices. At this regard it is significant to underline that the roughness is
8 not affected by the thickness of the samples (see Table 2).
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40 **Figure 3. Atomic Force Microscopy (AFM) morphology of $\text{Eu}(\text{TTA})_3\text{phen}$ -containing parylene film S1600.**

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43 Figure 4 shows the absorption and emission spectra of sample S320: the optical spectra of Eu film
44 are also reported for comparison.
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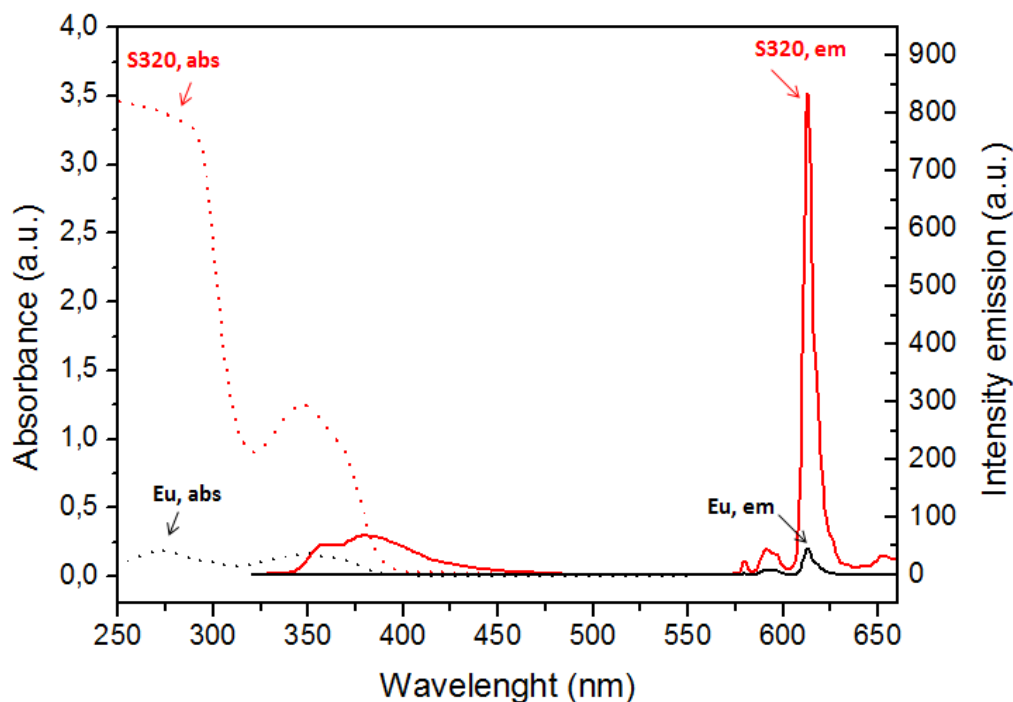


Figure 4. Absorption (abs) and emission (em) spectra of $\text{Eu}(\text{TTA})_3\text{phen}$ –parylene containing sample S320 (S320) and $\text{Eu}(\text{TTA})_3\text{phen}$ (Eu) film ($T = 20^\circ\text{C}$, $\lambda_{\text{ex}} = 270\text{nm}$).

S320 and Eu films show absorption spectra ranging from 250 to 400nm. The absorption of $\text{Eu}(\text{TTA})_3\text{phen}$ –parylene containing samples in the 250-300nm window avail itself of the presence of parylene matrix which absorbs in that region. This result is significant: parylene matrix, in fact, by absorbing UVB rays allows to improve the radiation hardness of $\text{Eu}(\text{TTA})_3\text{phen}$ molecules and to preserve the optical properties of PMMA waveguide.

S320 film shows the $\text{Eu}(\text{TTA})_3\text{phen}$ characteristic emission peaks at 580 nm, 591 nm, 613 nm, and 652 nm due, respectively, to the transition $^5\text{D}_0 - ^7\text{F}_0$, $^5\text{D}_0 - ^7\text{F}_1$, $^5\text{D}_0 - ^7\text{F}_2$, and $^5\text{D}_0 - ^7\text{F}_3$ of the Eu ion. In particular $\text{Eu}(\text{TTA})_3\text{phen}$ -containing parylene films are characterized by a Stokes shift (approximately 300 nm) extremely longer^{22,21} than common organic dyes such as Rhodamine 6G (21 nm)²² and Lumogen Red (33 nm)^{13,23}. Large Stokes shift implies the absence of absorption in the emission region of $\text{Eu}(\text{TTA})_3\text{phen}$ -containing parylene samples and is strategic in LSC field for developing novel devices free from self-absorption losses. Moreover it is important to note that the main emission peak of sample S320 (613 nm) is much higher than that of Eu film.

This superiority was analyzed by normalizing the luminescence intensity of S320 and Eu samples on the absorption peak intensity at 347nm, which is due to TTA molecules and depends on the quantity of $\text{Eu}(\text{TTA})_3\text{phen}$ molecules involved in the luminescence process. While the absorption intensity of S320 film at 347 nm is 8.3 times higher than Eu one, the ratio of S320 and Eu emission intensities at 613 nm is 18.5 times. This means that, under the same quantity of Eu complex, S320

film shows a luminescence more than two times higher than Eu sample. This much higher luminescence can be explained considering two different effects: i) $\text{Eu}(\text{TTA})_3\text{phen}$ molecules are uniformly dispersed in the parylene matrix, therefore quenching effects are prevented; ii) parylene plays an active role in the luminescence process. In fact, as evidenced by Figure 5, parylene exhibits an intrinsic emission in the (340-425 nm) window: the photons emitted by parylene matrix are absorbed by the TTA molecules and re-emitted at the characteristic emission peaks going from 582 nm to 652 nm by Eu atoms. This host-guest energy transfer can be noted by comparing the shape of the emission spectra of S1600 and PARY samples. In particular it is possible to note that the emission intensity ratio between the peaks at 360 nm and 380 nm of S1600 sample (0,77) is sensitively lower than that of sample PARY (0,96). The absorption spectrum of $\text{Eu}(\text{TTA})_3\text{phen}$ complex clearly demonstrates that the $\text{Eu}(\text{TTA})_3\text{phen}$ molecules absorb part of the photons emitted by parylene.

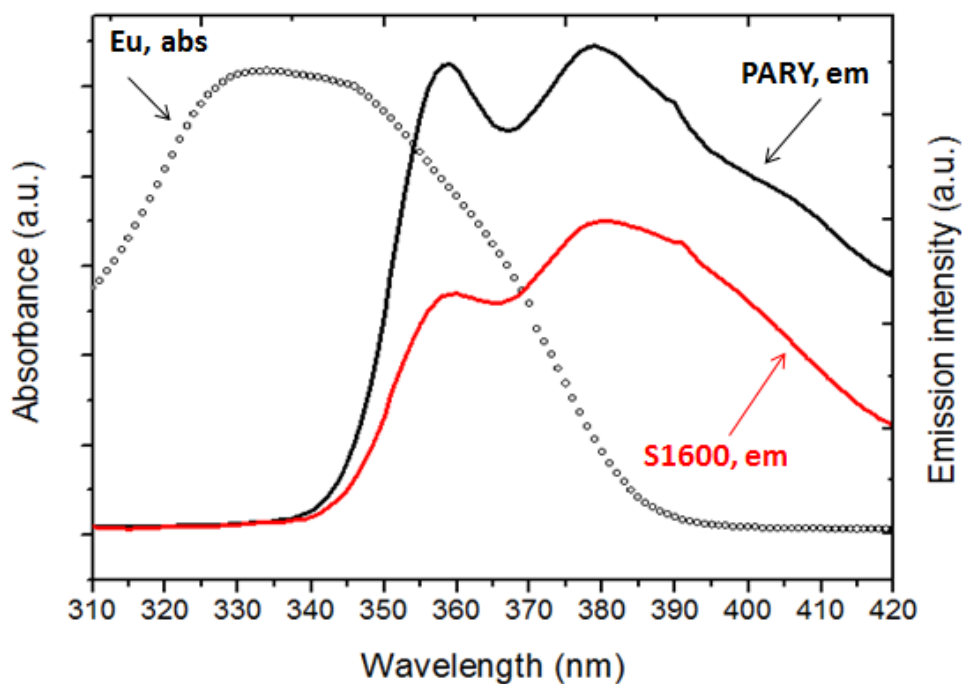


Figure 5. Absorption spectrum of $\text{Eu}(\text{TTA})_3\text{phen}$ (Eu, abs) films and emission spectra of $\text{Eu}(\text{TTA})_3\text{phen}$ – parylene containing (S1600, em) and parylene films (PARY, em) over the 310-420 nm window ($T=25^\circ\text{C}$; $\lambda_{\text{ex}} = 270$ nm).

The data demonstrate that the role of the parylene matrix is innovative and strategic in LSC field. In fact, it absorbs UVB rays allowing to shield both $\text{Eu}(\text{TTA})_3\text{phen}$ molecules and PMMA substrates from their interaction and, at the same time, it improves the final performances of the devices by allowing a better conversion of the UV window of the solar spectrum. Moreover, as several other

dyes can be co-sublimated into parylene films, the approach used in this work can open the way for the production of a new class of improved LSC materials.

I-V performances of LSCs under AM 1.5G

In order to evaluate the performances of the produced LSCs, the I-V curves under AM 1.5 G solar illumination were measured: Figure 6 shows the output power of the devices as a function of the thickness of the $\text{Eu}(\text{TTA})_3\text{phen}$ -containing parylene films.

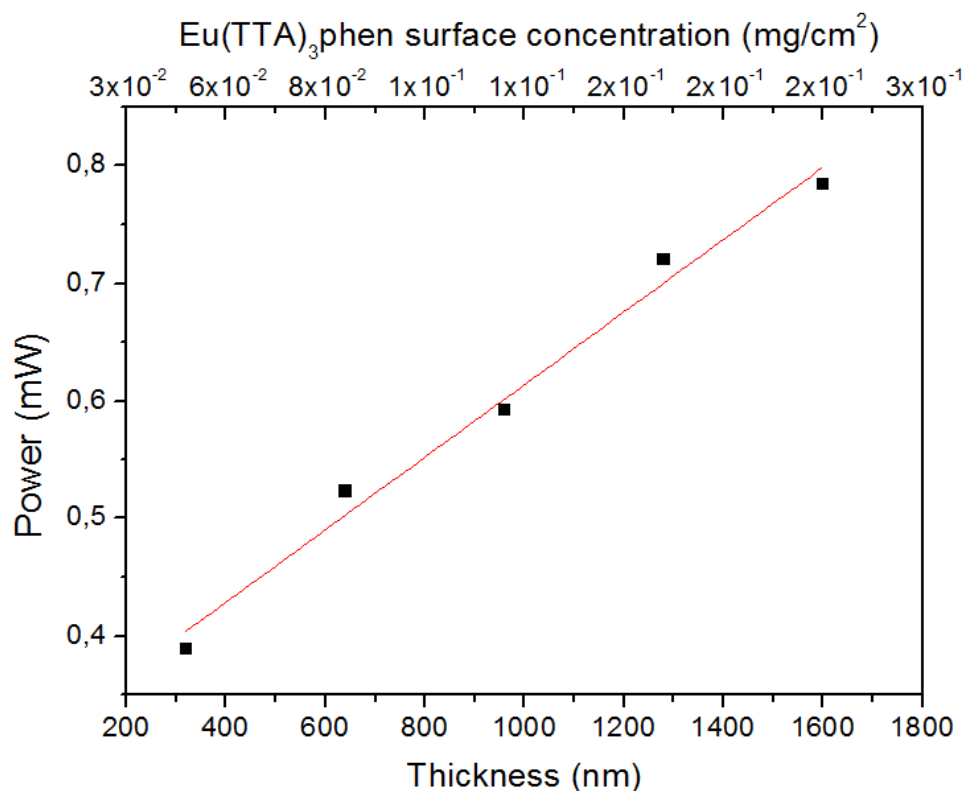


Figure 6. Output power of $\text{Eu}(\text{TTA})_3\text{phen}$ – containing parylene based LSCs as a function of the thickness of the films and of the $\text{Eu}(\text{TTA})_3\text{phen}$ surface concentration. Measurements were carried out under solar simulator at AMG1.5, $T=25^\circ$. The red line represents the linear fitting of the curve.

The LSC power increases with the thickness of the films up to the maximum thickness (1600 nm), as the $\text{Eu}(\text{TTA})_3\text{phen}$ surface concentrations of the films (ranging from $0.45 \cdot 10^{-4} \text{ g/cm}^2$ to $2.24 \cdot 10^{-4} \text{ g/cm}^2$) are not enough to completely absorb the solar radiation in the absorption region of $\text{Eu}(\text{TTA})_3\text{phen}$. This finding agrees with other literature data in which the minimum $\text{Eu}(\text{TTA})_3\text{phen}$ concentration for assuring the full absorption is indicated to be $4.2 \cdot 10^{-4} \text{ g/cm}^2$ ²⁴. It is worth to note that the LSC output power linearly increases with the film thickness: this behavior testifies that every $\text{Eu}(\text{TTA})_3\text{phen}$ molecule gives the same contribute to the LSC power independently by its

distance from the PMMA substrate and indicates that the $\text{Eu}(\text{TTA})_3\text{phen}$ -containing parylene films are not affected by self- sorption losses.

Table 3 reports the main parameters of sample S1600. The optical efficiency (η_{opt}) and the power conversion efficiency (η_{LSC}) were calculated according to the definitions reported in literature^{13,25}.

Sample	S1600
Substrate	PMMA
LSC sizes (mm ³)	50*50*5
Cell	silicon
η_{cell} (%)	14.3
Isc (mA)	4.34
Voc (mV)	438
FF	0.63
η_{opt}	2.47
η_{LSC}	0.19

Table 3. Features and electrical parameters of $\text{Eu}(\text{TTA})_3\text{phen}$ -containing parylene based S1600 LSC.

The comparison with literature data²⁴ shows that S1600 sample is characterized by a power conversion efficiency (η_{LSC}) 50% higher than conventional $\text{Eu}(\text{TTA})_3\text{phen}$ – based LSCs. This result is even more important taking into account that the $\text{Eu}(\text{TTA})_3\text{phen}$ surface concentration of sample S1600 ($2.24 \cdot 10^{-4} \text{ g/cm}^2$) is much lower than that of the literature samples ($4.2 \cdot 10^{-4} \text{ g/cm}^2$). The superiority of $\text{Eu}(\text{TTA})_3\text{phen}$ – containing parylene films clearly demonstrates the good quality of the parylene-based luminescent films, in which $\text{Eu}(\text{TTA})_3\text{phen}$ molecules are finely dispersed, and the active role of parylene matrix in improving the LSC external quantum efficiency (EQE) by absorbing UV light and transferring it to $\text{Eu}(\text{TTA})_3\text{phen}$ molecules. The photons not re-absorbed by Eu complex are moreover transmitted within the waveguide bringing an additional contribution to the efficiency of the device.

The variation of the electrical characteristics as a function of the LSC size is a very important feature in LSC field in order to analyze the feasibility to produce large size modules. In agreement with other works^{26,24}, in this work it was in depth investigated through the setup described in Figure 7a. In this setup the illuminated area was changed using a black blind placed on the top of the LSC device. I-V measurements were recorded for each area size ranging from 5 to 25 cm². Figure 7b displays the open circuit voltage, Voc, and the short-current density, Jsc, measured for each particular illuminated area of the fluorescent concentrator.

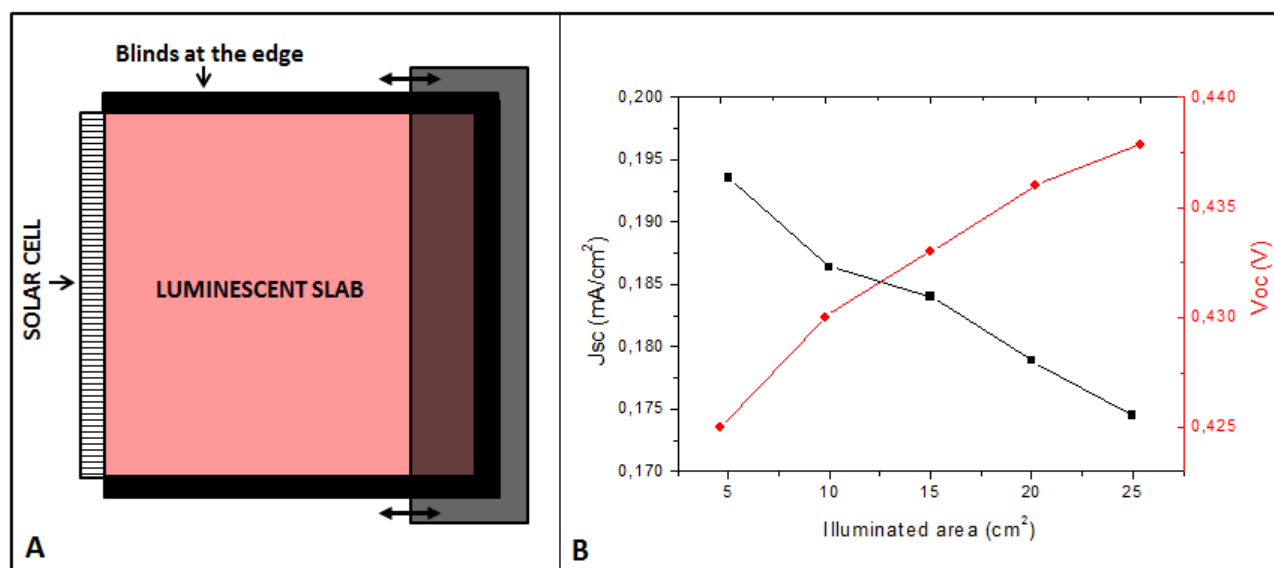


Figure 7. (A) Sketch of setup used for measuring the variation of I-V performance of LSC with different radiation area. The radiation area was changed by 1 cm steps by using a covering black blind. (B) Short circuit current, JSC (black), and open circuit voltage, VOC (red), of S1600 LSC as a function of the radiation area. Measurements performed with solar simulator under AM1.5G.

The voltage increases with increasing size since more light reaches the collector. The total current also increases while the short-circuit current density (Jsc) slightly decreases with increasing area.

Nevertheless it is important to note that Jsc of Eu(TTA)₃phen-containing parylene based LSCs decreases approximately ten times lower (0,004 cm⁻¹) than the dye-based LSC (0,037 cm⁻¹)^{Error!}. This feature is strategic for developing competitive LSC devices and is related to the absence in these devices of self-sorption losses. In fact, Jsc is related to the probability for a photon emitted in a position of the LSC device to reach the solar cell placed on the edge: the large Jsc decrease occurring in dye-based LSC is due to the parasitic re-absorption and re-emission events which become more likely to happen with increasing path length of the photon. The slight Jsc decrease of Eu(TTA)₃phen-containing parylene based LSCs can be imputed to the host absorption losses of PMMA slab.

The most significant performance in evaluating a LSC device is the trend of the power conversion efficiency (η_{LSC}) as a function of the size. The η_{LSC} variation of Eu(TTA)₃phen – containing parylene- and dye-based LSCs was normalized and reported in Figure 8.

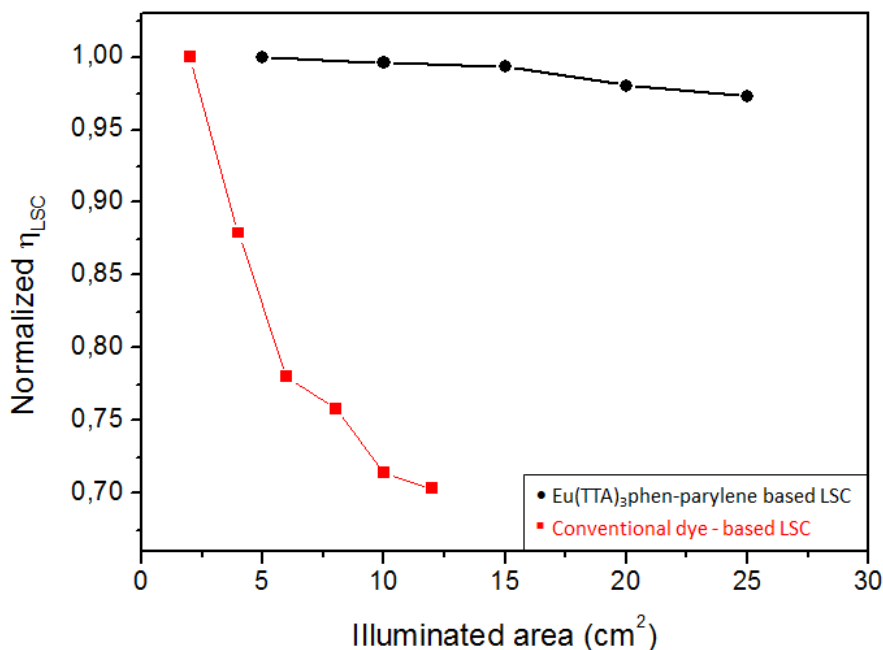


Figure 8. Variation of normalized power conversion efficiency (η_{LSC}) of S1600 - based (black) and dye – based (red) LSCs as a function of the illuminated area of LSC. Dye – based LSC data were extrapolated by ref. [Error! Bookmark not defined.].

The comparison clearly shows that while the dye-based LSC is characterized by an average efficiency decrease of 2.5 % every cm², Eu-based LSCs are characterized by an average efficiency decrease 25 times lower (0.1 % every cm²). This result, which is due to the absence of self-absorption losses, is really significant since it gives way to the possibility to produce large size LSC devices characterized by the same electrical features of small samples.

Conclusions

In this work new Eu(TTA)₃phen -containing parylene thin films were grown by a new solvent-free co-deposition process on PMMA substrates in order to produce novel luminescent solar concentrators.

The feasibility of the deposition process was demonstrated for the first time and the calibration of the process was performed. The features of the samples were analyzed by infrared analysis (FT-IR), atomic force microscopy (AFM), optical absorption and emission spectroscopy. FT-IR analysis demonstrated the integrity of the vacuum sublimated Eu(TTA)₃phen molecules within the films. AFM measurements showed the very flat surface of the films (Rq=3.7 nm) which is strategic in LSC devices for minimizing the light scattering at the air/film interface. The optical analyses

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2
3 highlighted that the absorption and luminescence spectra of the rare earth complex are not affected
4 by the matrix interaction preserving the peculiar large Stokes shift (270nm) of $\text{Eu}(\text{TTA})_3\text{phen}$
5 compound. Moreover the occurring energy transfer process between parylene and Eu complex
6 strongly improves the final luminescence of the sample: in fact, with an equal quantity of Eu
7 complex, $\text{Eu}(\text{TTA})_3\text{phen}$ -containing parylene films show a luminescence more than double with
8 respect to conventional $\text{Eu}(\text{TTA})_3\text{phen}$ films.
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11 The current-voltage (I-V) capabilities of samples showed that, for the same quantity of Eu complex,
12 $\text{Eu}(\text{TTA})_3\text{phen}$ – containing parylene films exhibit a current density more than two times higher
13 than conventional $\text{Eu}(\text{TTA})_3\text{phen}$ based LSCs. This result demonstrates the active role of parylene
14 matrix and the quality of the novel co-deposition process which allow to grow very flat films with
15 finely dispersed luminescent dyes. The I-V performances of the samples as a function of the
16 radiation area was finally investigated and compared to those of LSCs employing conventional
17 dyes. The data highlighted that the efficiency of $\text{Eu}(\text{TTA})_3\text{phen}$ -containing parylene films decreases
18 twenty times slower than conventional dye-containing LSCs with the increment of radiation area.
19 This result can be attributed to the absence of overlaps between absorption and emission peaks and
20 is very promising for developing large size LSCs. By considering that numerous other dyes can be
21 co-sublimated within parylene matrices, the approach used in this work can open the way to the
22 production of a new class of improved LSC materials.
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