Investigating novel dyes for indoor DSSCs : study of the devices long-term performance upon bufexamic acid pre-adsorption

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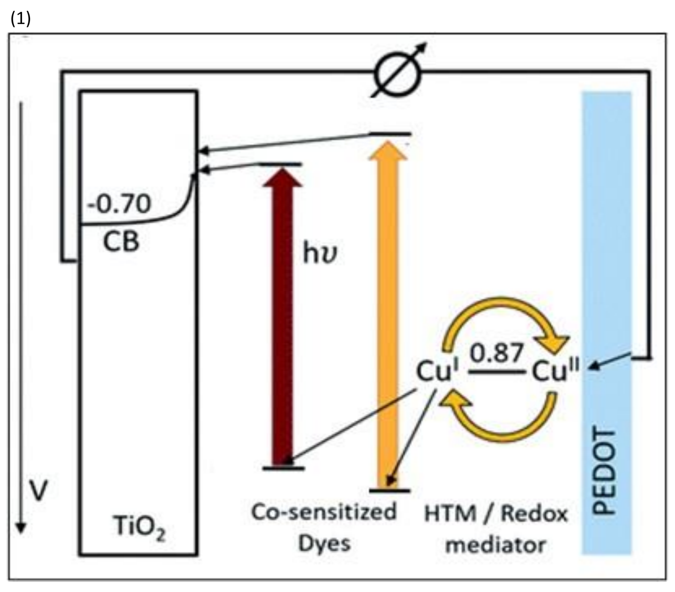
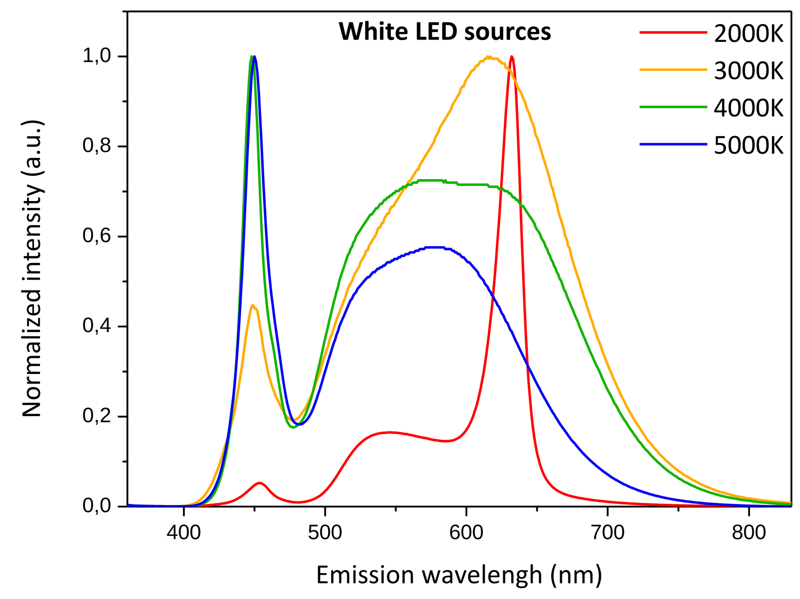
Background and approach

Introduction

The Internet of Things is growing tremendouly, and the question of powering many small, connected devices has recently arisen.
Unlike other PV technologies, Dye Sensitized Solar Cells (DSSCs) are able to efficiently convert diffuse and weak light, while being industrially produceable. Thus, DSSCs can be designed to convert ambient light and désigne be suitable for individually powering these smart items[1].



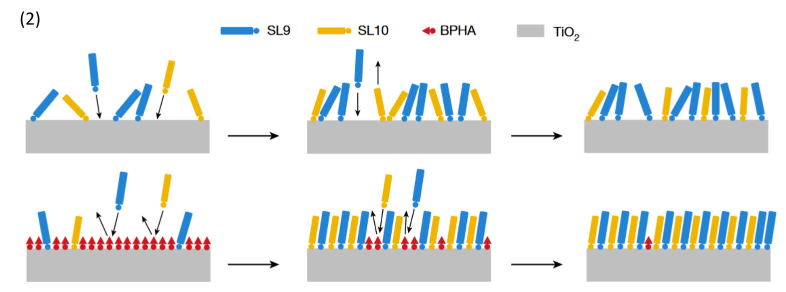
In indoor PV, a white LED light source is generally considered. Hence, the photoactive sensitizers that convert light should be able to efficiently absorb the wavelengths emitted by the LEDs, depending on the source temperature.



The role of BPHA is to provide better close packing of the sensitizers at the surface of the photoanode, and to potentially prevent dye-electrolyte electron recombination.[3]

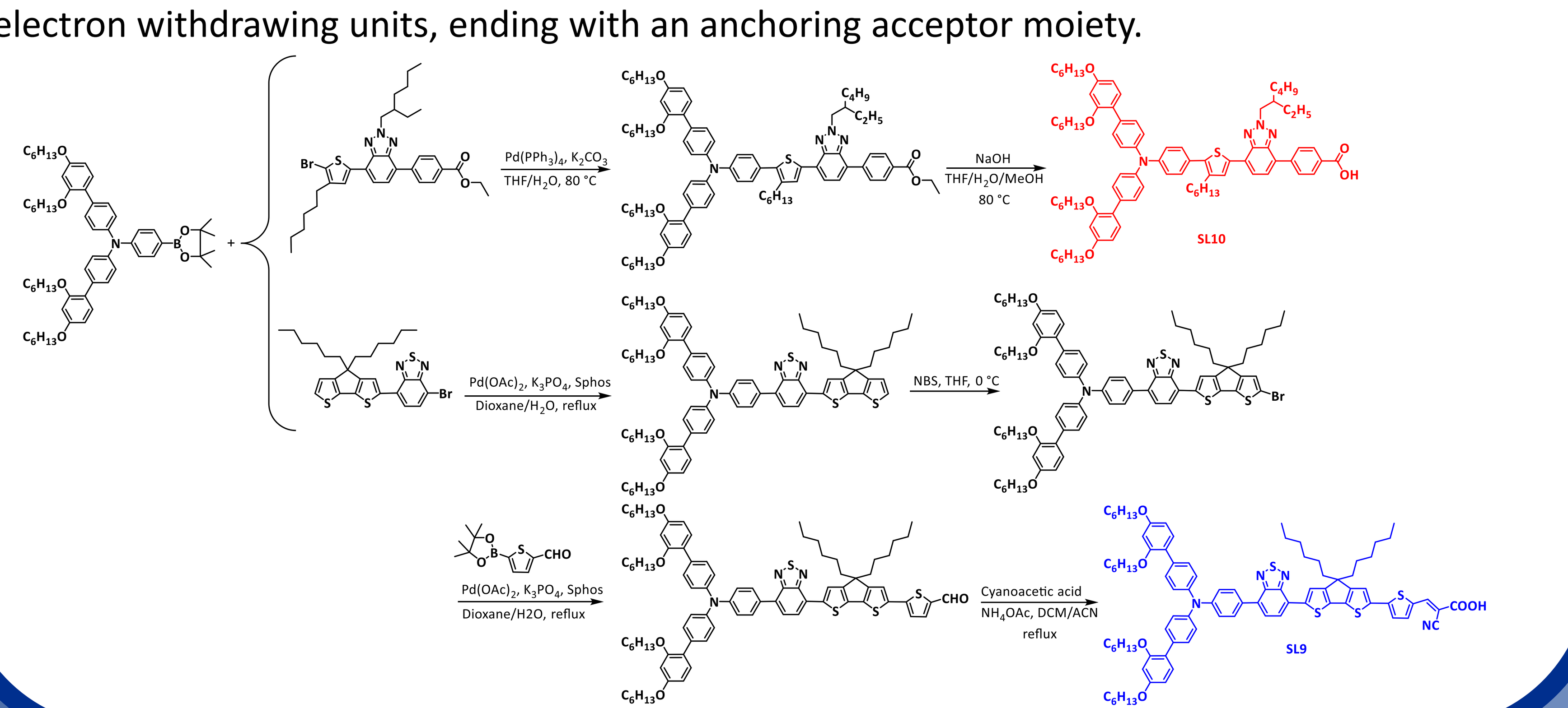
Objectives

SL9 and SL10 are two recently published dyes[2] that were used in co-sensitized indoor DSSCs. They were integrated in industrially-processed devices and their performance and stability was assessed. On the other hand, the effect of 2-(4-Butoxyphenyl)-N-hydroxyacetamide (BPHA) as a pre-adsorber was investigated.



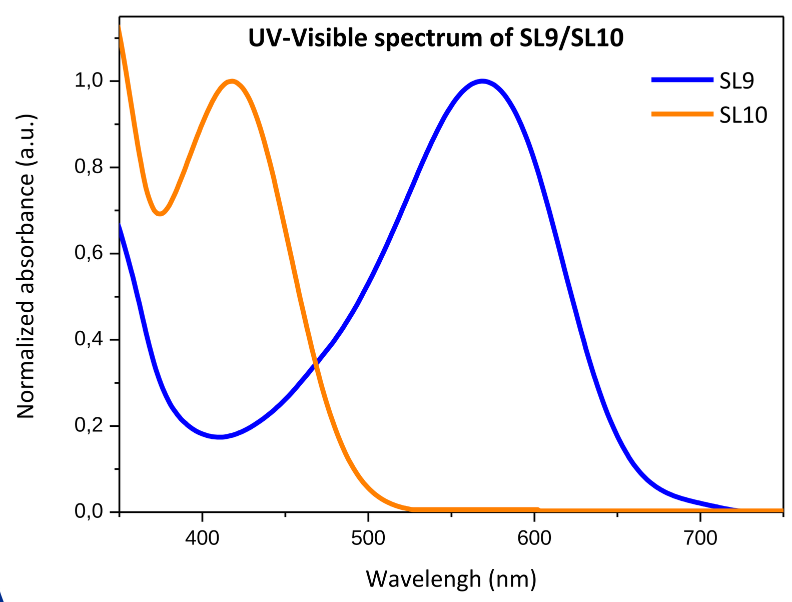
Synthesis of the sensitizers

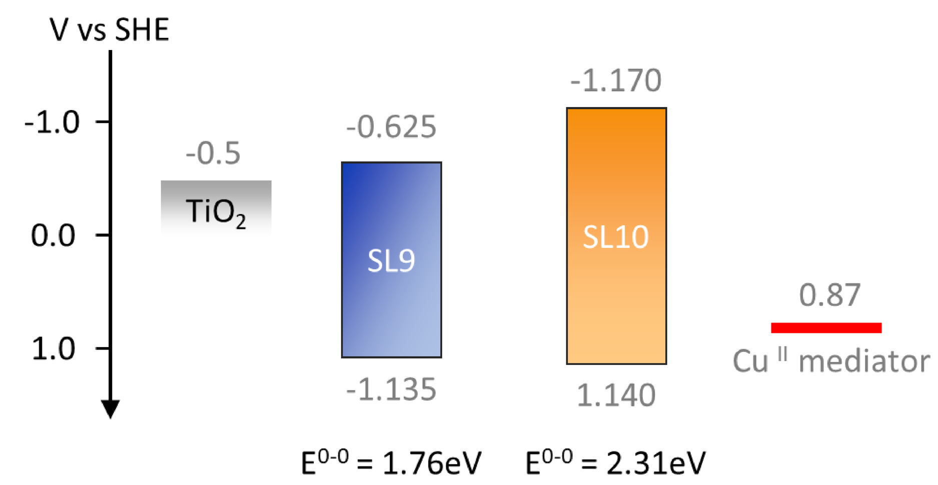
SL9 and SL10 were first synthetized over the course of 15 synthetic steps. The so-call push-pull dyes are composed of an electron-rich part, while the second part is composed of several electron withdrawing units, ending with an anchoring acceptor moiety.



Characterisation

Both dyes structures were confirmed by ^{1}H, ^{13}C NMR and High Resolution Mass Spectrometry.
The optoelectronic properties of SL9 and SL10 were characterized by UV-Visible spectroscopy and Cyclic Voltammetry, to determine their HOMO and LUMO energy levels.



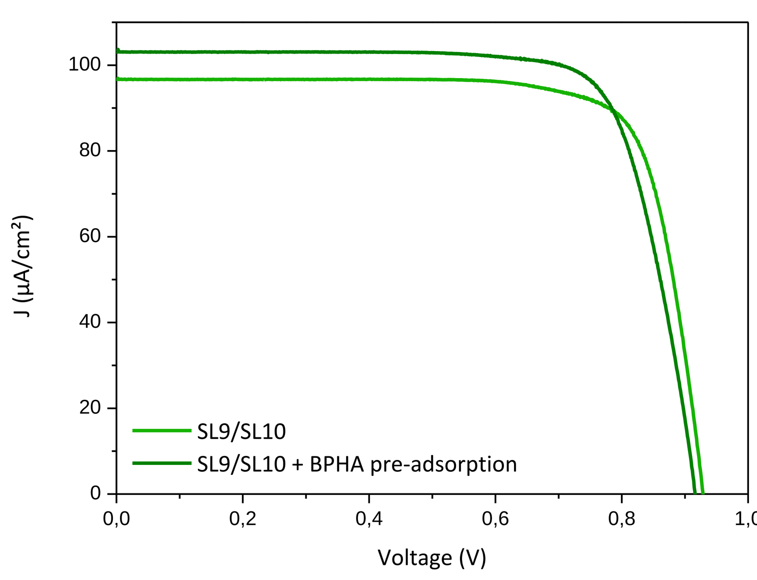


Results and conclusions

Champion cells performance

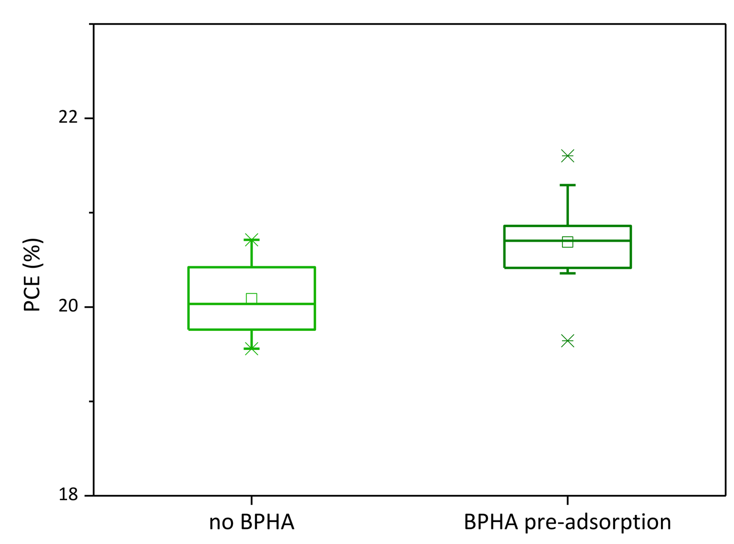
The DSSCs based on SL9 and SL10 were able to reach up to more than **25 %** efficiency under *1000 lux (3000K white LED light source)*, achieving performance similar to commercial devices. BPHA reliably improved the J_{SC}, while no highly detrimental effect was observed.

	V_{oc} (V)	J_{SC} (µA/cm²)	FF	PCE (%)
SL9/SL10	0,928	96,7	0,784	24,3
SL9/SL10 + BPHA pre-adsorption	0,916	103,1	0,768	25,0



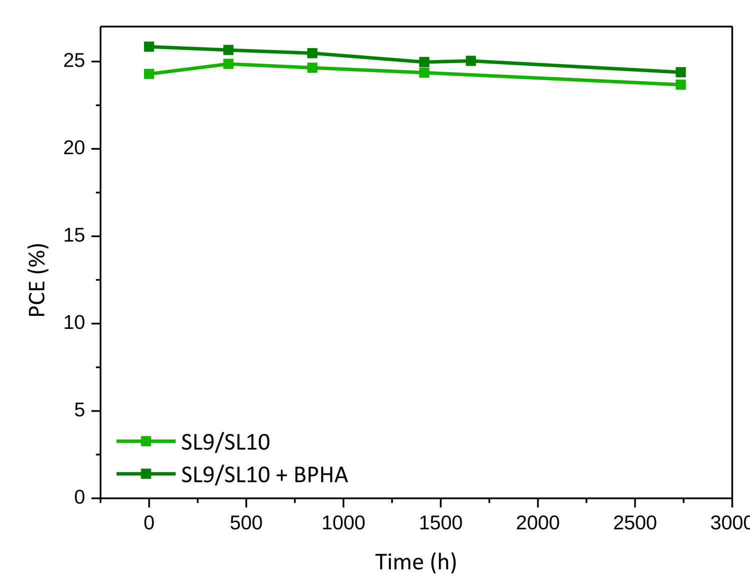
Sampling

A set of 20 standard and pre-adsorbed SL9/SL10 cells was fabricated in order to reliably evaluate the benefits of BPHA. In average, pre-adsorbing BPHA before sensitization **increased the PCE by about 0.7%,** while the Fill Factor was also surprisingly enhanced by a few percents.



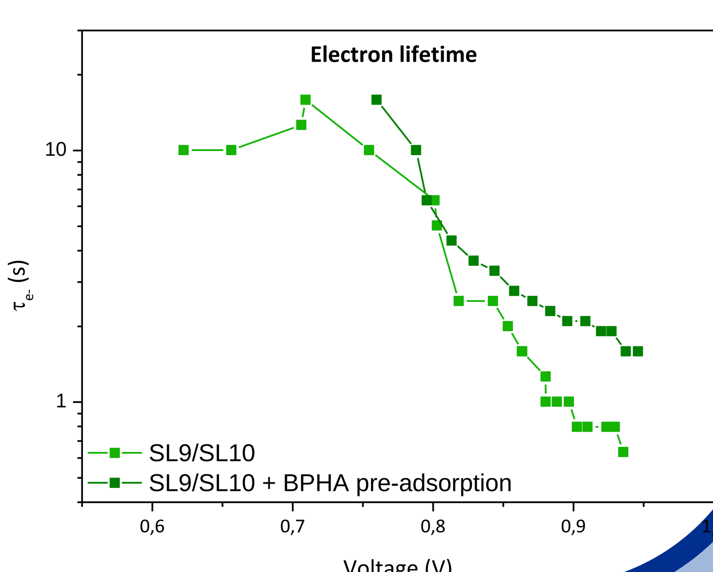
Stability

While kept under ambient conditions, the cells showed good stability with more than **95% of PCE retention** after reaching **3000h**. BPHA did not have any relevent effect on the stability. The same experiments were conducted in harsher conditions (kept @ 60°C, 1sun / 70°C, dark), and **BPHA did not show any determental effect** either.



Intensity Modulated Photovoltage Spectroscopy

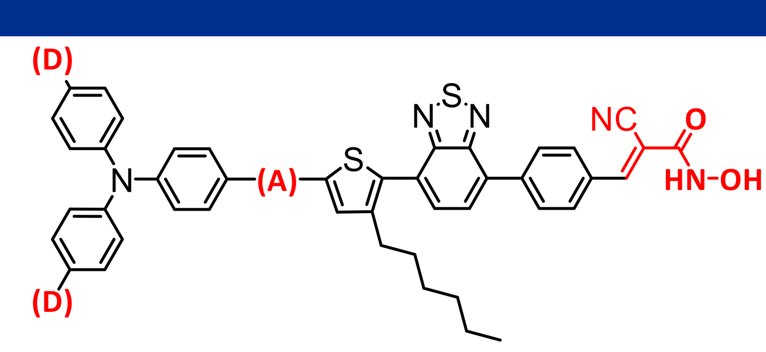
In addition to the electron lifetime of the dyes in solution, IMPS was used to evaluate the effect of BPHA on the electron lifetime inside the devices. After 0.8V, the bufexamic acid pre-treatment appears to **prevent charge recombination** at the interface of the photoanodes.



Prospectives

The synthesis of several SL9-like dyes is currently ongoing. Several strategies are explored to better the spectral response of the dyes and/or to unfavorize charge recombination, namely:

- Modifying the carboxylic acid anchoring acceptor
- Trying alternative triphenylamine-based donor moieties
- Incorporating an extra acceptor group to extend the spectral absorption



References
[1] H. Michaels *et al.*, *Chem. Sci.*, **2020**, *11*, 2895–2906.
[2] Y. Ren *et al.*, *Nature*, **2023**, *613*, 60–65.
[3] S. H. Aung *et al.*, *ACS Omega*, **2017**, *2*, 1820–1825.

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