Surface Engineering of Solid-State Dye-Sensitized Solar Cells

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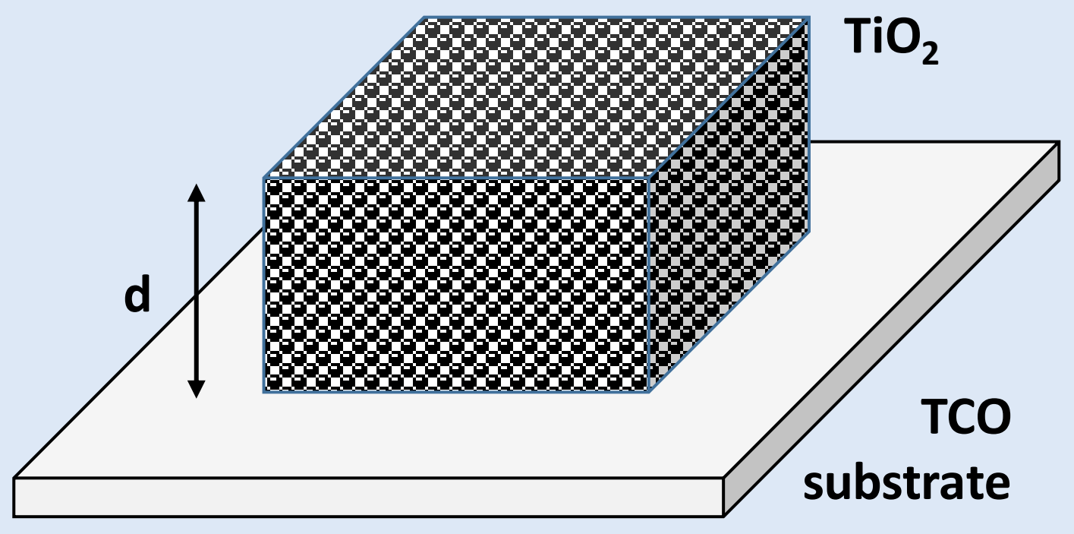
Abstract

The way that molecules interact with interfaces play a key role in the manufacture and performance of solid-state dye-sensitized solar cells (ssDSC). In order to maximise the performance of ssDSC, it is important to understand the interactions and to subsequently optimise them. The key interactions within the process, are the wetting and subsequent dyeing of the TiO_2 layer by immersion dyeing, ultra-fast pump dyeing or spin coating. During the device making process, the dyes will arrange themselves in the configuration that results from lowest energy orientation, even if this is less favourable in terms of device performance[1, 2, 3]. This poster describes our current work on the effect of TiO_2 thickness on dye loading and device performance.

Introduction

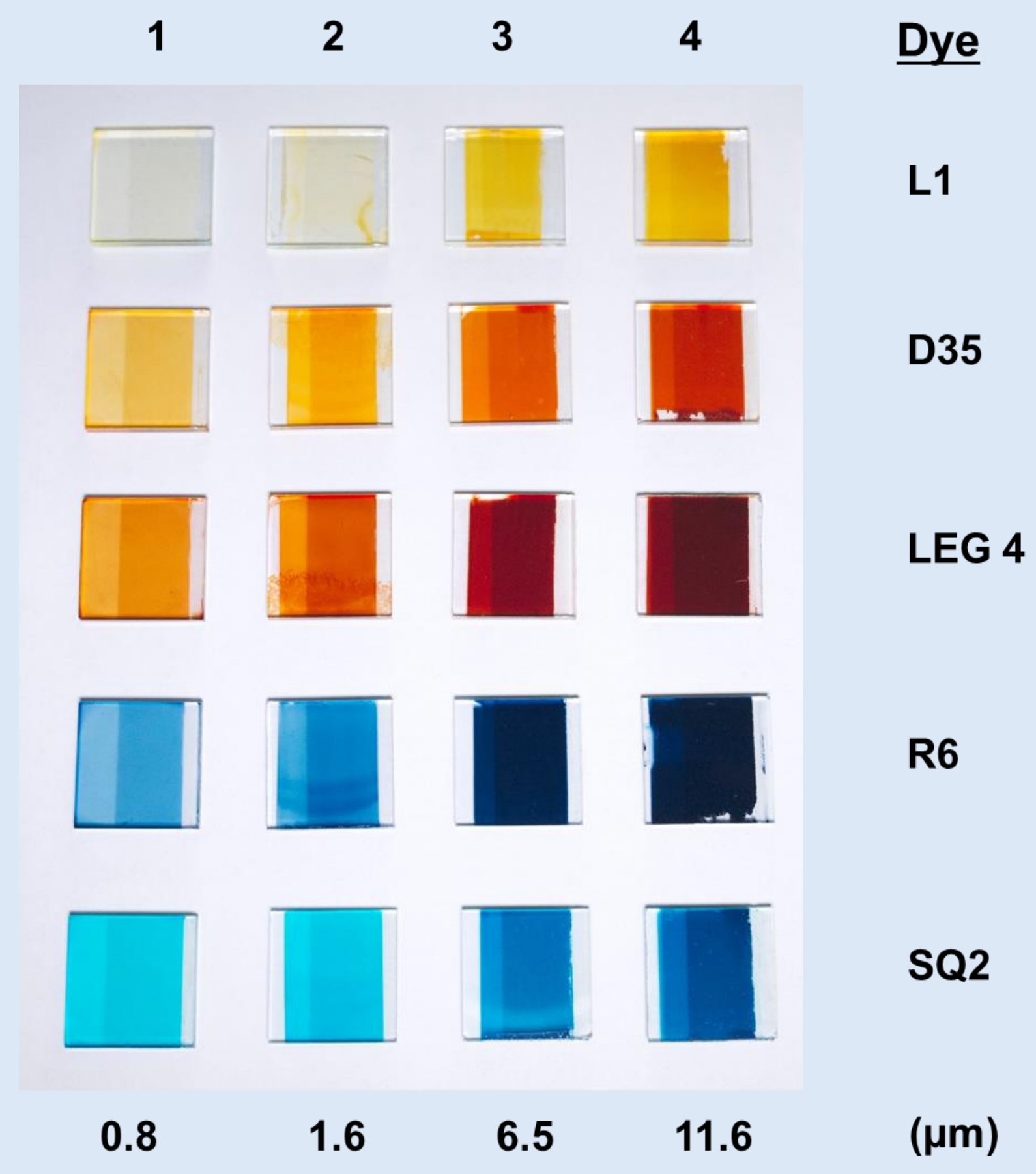


Electrical and optical losses lower device power conversion efficiency[4]. Thus, optimising device structure is key in maximising efficiency and light harvesting. Factors that contribute to this include titania thickness, dye ε and optical density. As efficiency is a result of the function of both optical bandgap and the loss-in-potential, if voltage losses can be reduced device efficiency should increase.

Surface interaction of molecules also play a key role in the performance of dye cells, thus it is key to understand these interactions when optimising device structure.

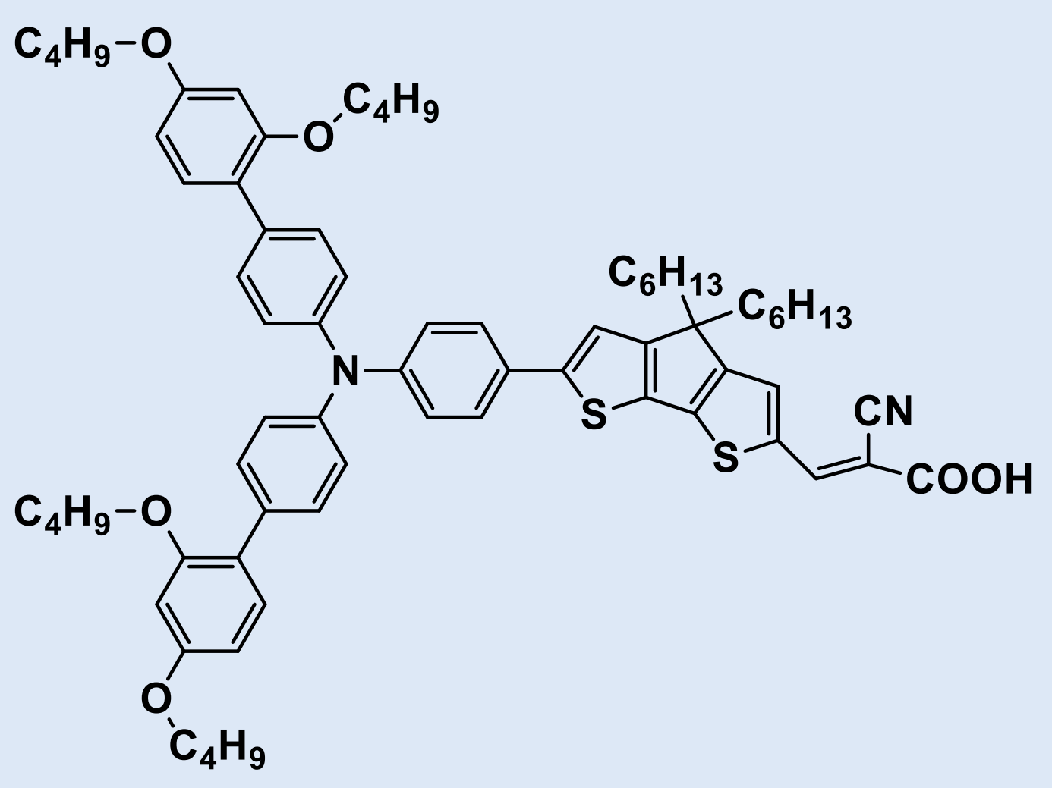
Experimental

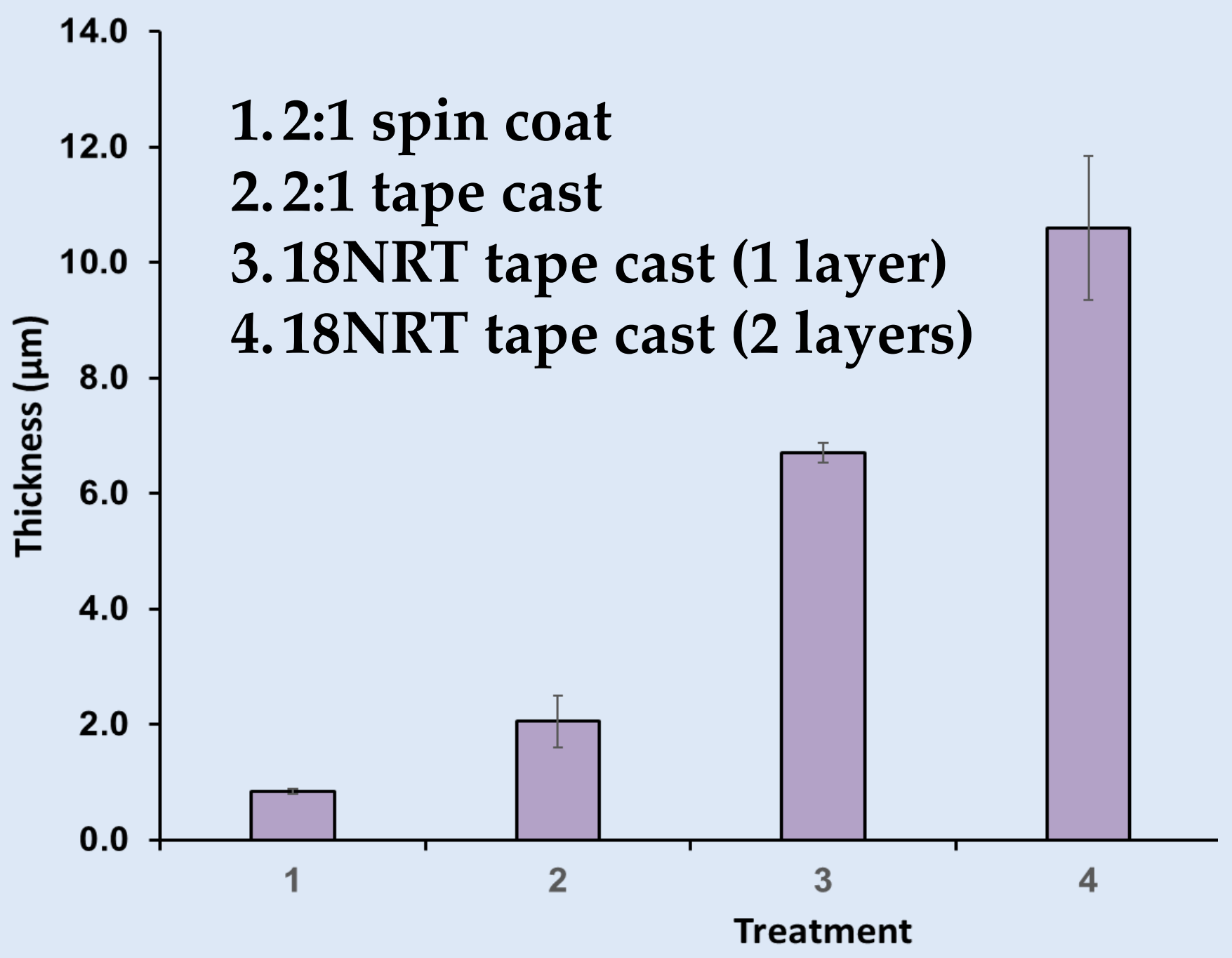
Substrates were cleaned in acetone and O_2 plasma before a TiO_2 blocking layer was spin coated at 5000 rpm for 30 s with 2000 rpm s^{-1} acceleration and sintered at 550˚C. Mesoporous titania electrodes were then prepared with 4 deposition methods to achieve different thicknesses of titania (0.8µm, 1.6µm, 6.5µm and 11.6µm) and sintered at 550 ˚C. The TiO_2 electrodes were dyed in a 0.5mM dye bath for 12h. 150mM Spiro-OMeTAD (doped with 20mM LiTSFI and 200mM TBP) was deposited as the HTM and gold contacts were evaporated onto the device.



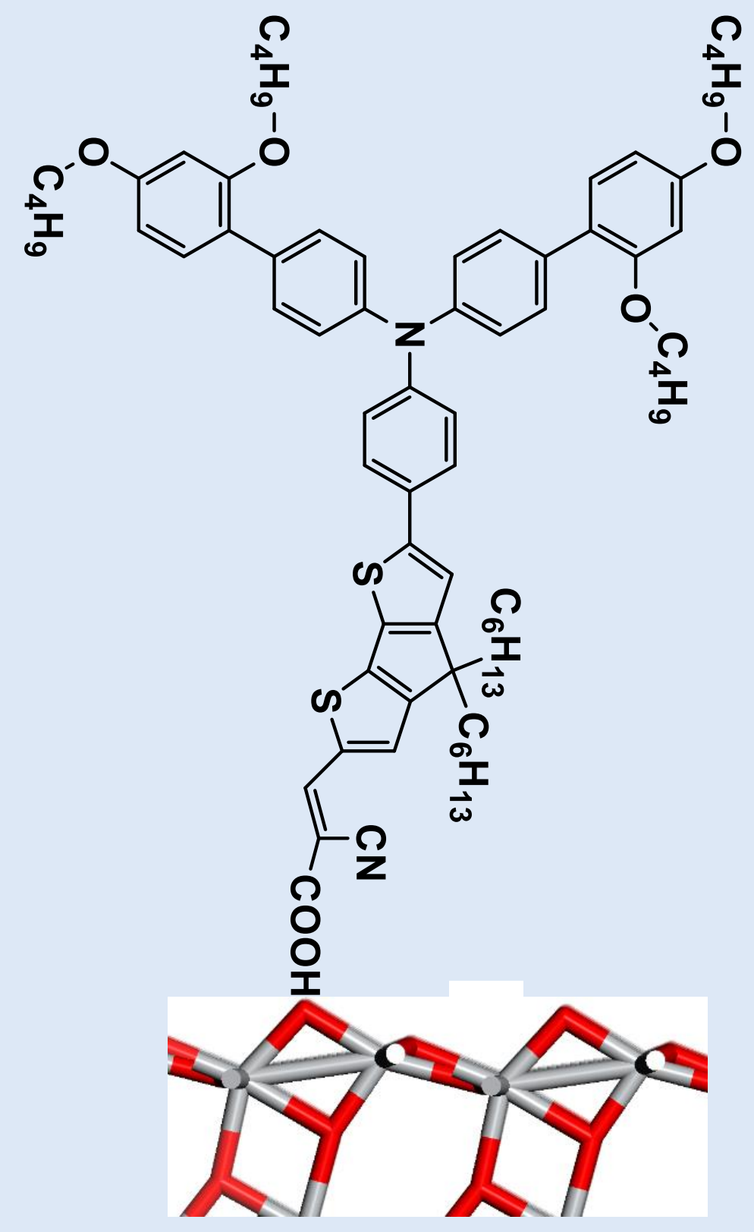
Results and Discussion

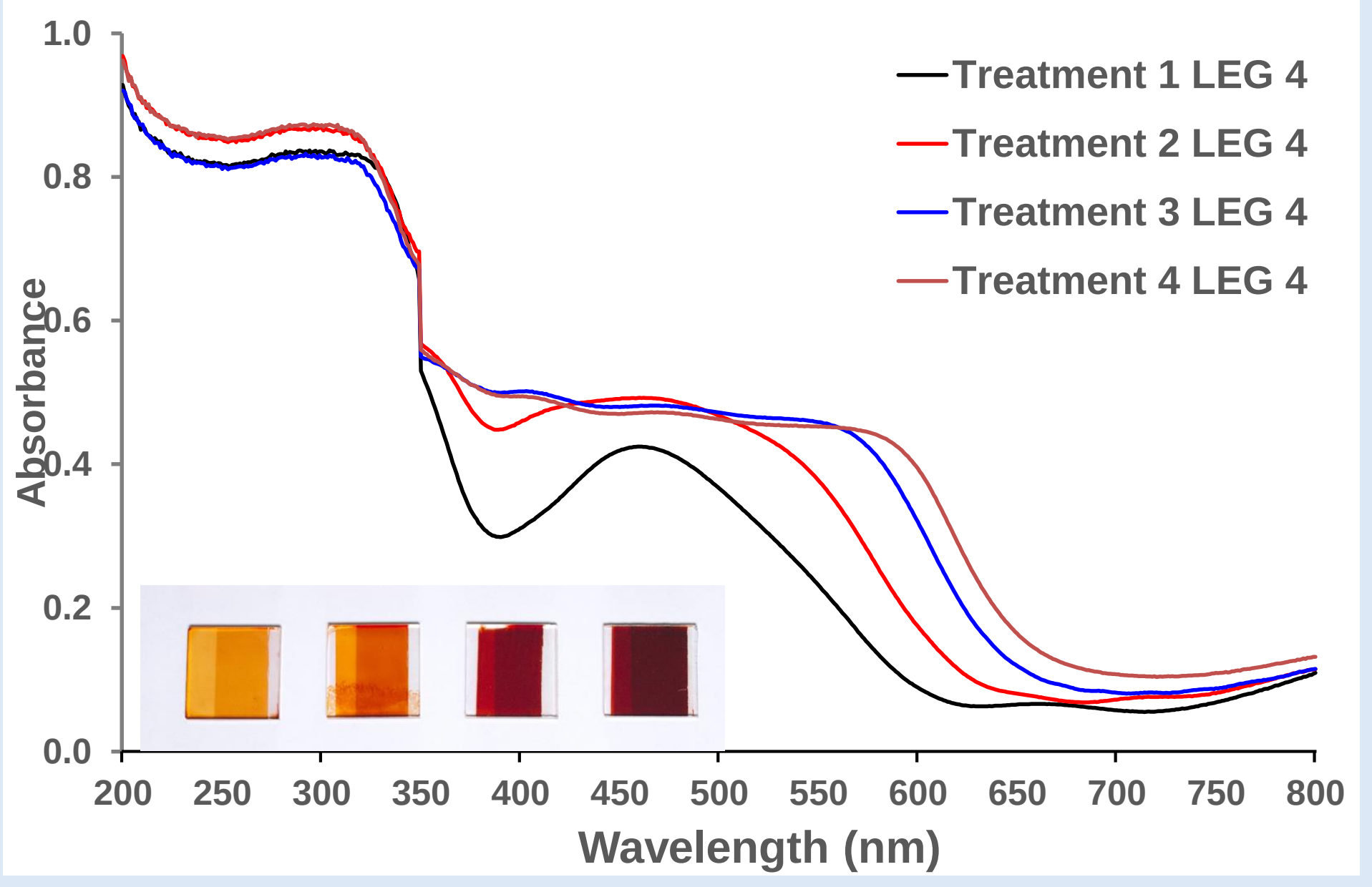
Highest performing LEG 4 devices, in terms of η (%), J_{sc} and V_{oc}, were those with the thinnest (0.8µm) titania layer.



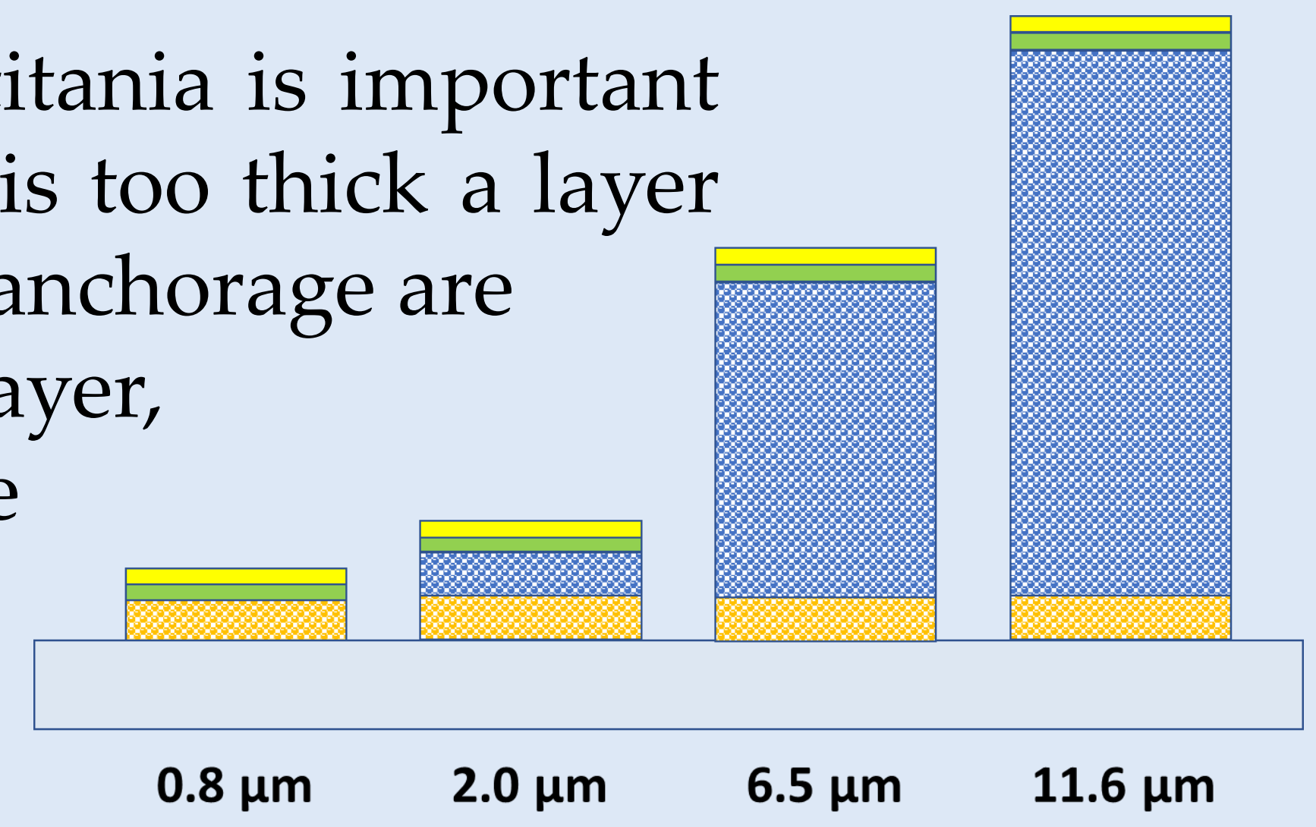


Thickness (µm)	J_{SC} (mA cm^{-2})	V_{oc} (V)	FF	η (%)
0.8	10.00	1.00	0.39	3.9
1.6	5.68	1.00	0.53	3.0
6.5	9.45	0.90	0.29	2.5
11.6	1.86	0.98	0.39	0.7

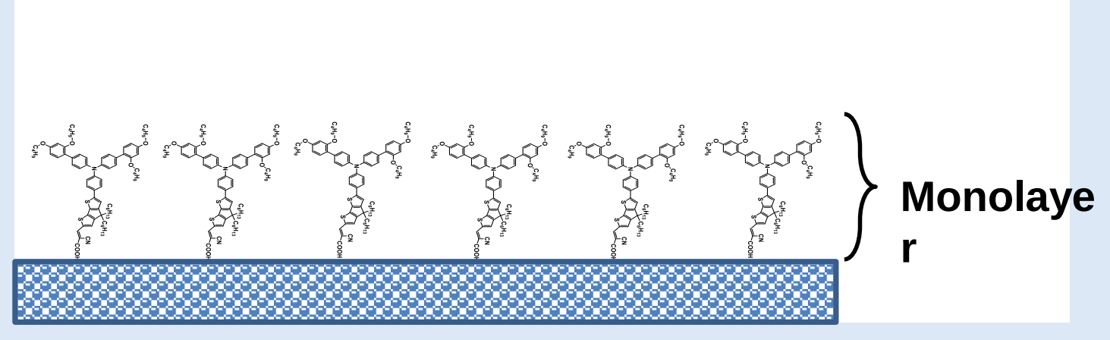


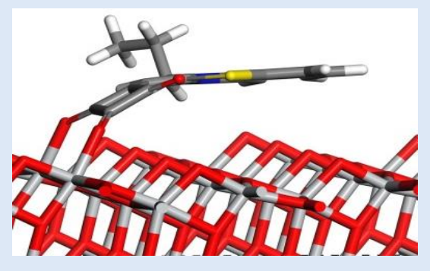


Surface orientation of dyes on titania is important to device performance. If there is too thick a layer of titania, the extra sites for dye anchorage are overcome by a large insulating layer, whilst the HTM cannot percolate through to fill all of the pores.



Conclusions and next steps





- Optimisation by minimising voltage losses (energy level alignment).
- Dye loading: extinction coefficients ⟶ optical density
- Orientation – what really is a monolayer?

Acknowledgments
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