

New co-Adsorption Strategy for Efficient Dye Sensitized Solar Cells

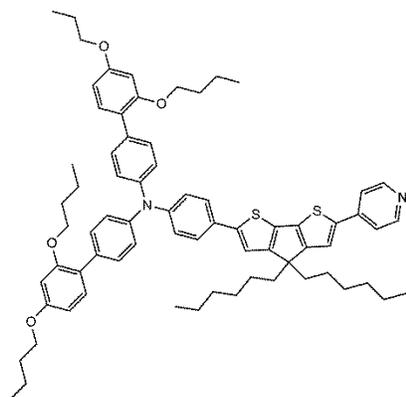
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Dye-sensitized solar cells (DSSCs) have attracted much attention due to their relatively low cost, acceptable conversion efficiency and ease of fabrication.¹ Several attempts were made in order to increase the light-harvesting efficiency of solar cells mainly the engineering of panchromatic dyes (sensitizers).² One of the main functional moieties in a sensitizer is the anchoring group; the group that functions as the adsorption site of the dye to the semi-conductor. In the chemical literature many examples of anchoring groups have been proposed, ranging from carboxylic and phosphonic acids to pyridyl, N-oxide and azoles.³ Out of the different anchoring groups, the carboxylic acid groups are what mainly used in most dyes due to their efficient electron injection and their effect on shifting the main absorption bands towards the red. The carboxylic acid anchoring groups mainly adsorb to the Brønsted acid sites (Ti-OH site) in TiO₂, which ranges between 66 to 75% of the total sites. However, there are ~ 30-25% Lewis acid sites (Ti³⁺) in TiO₂ that are usually free in assembled DSSC's or protected by the common additive *t*-butylpyridine (TBP) that adsorbs at these Lewis acid sites, and in fact most of pyridine containing dyes adsorb to these sites as has been shown recently by Harima et al.⁴

In the literature there are many examples of co-sensitizing dyes in a DSSC to enhance the overall efficiency of the DSSC and to absorb a large fraction of the visible and near-IR light and convert it to current.⁵ However, one drawback of this approach is the fact that the dye and co-sensitizer compete for the same Ti-OH binding sites and therefore the amount of the main dye gets lower as the co-sensitizer adsorbs more.

Herein, we present a new strategy of co-adsorbing complementary dyes while the first being a commercially available and efficient blue dye (such as Dyenamo Blue, DB) or a green dye (such as YD2 or Black Dye) and a new efficient organic dye synthesized in-house with a pyridyl anchoring group (**T181**, scheme 1). The complementary dyes are shown not to compete for the same adsorption site and thus the loading of the carboxylic acid based dye does not diminish upon co-adsorption while the total loading of dyes increases. In addition, such a strategy shows profound positive effects on the DSSC's performance, in some cases on the open-circuit voltage (*V*_{oc}), and in others on the photo-current (*J*_{sc}) or both.



Scheme 1: T181 dye structure.

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