Enhancing Conversion Efficiency of Dye-Sensitized Solar Cells by Synthesis of Highly Ordered Titania Structures and Judicious Selection of Redox Couples

The objective is to use TiO_2 nanowire arrays (top of Fig. 1) as the dye host, whose ordered structure allows easy access of surface modification agents to effectively block the recombination reaction of injected electrons and the oxidized form of redox couple in the electrolyte. Organosilane of different thicknesses was deposited onto the nanoarrays in different cycles of coatings. Our results (bottom of Fig. 1) indicate that the voltages of our dye-sensitized solar cells (DSSCs) increase with the number of organosilane coatings, and the current density is the highest when only three layers of coatings were applied. Thus, coating the nanoarray surface with organosilane molecules is an effective way to block the hole/electron recombination process, while a very thick coating might impede the electron transfer between the nanoarray and the redox species in solution.

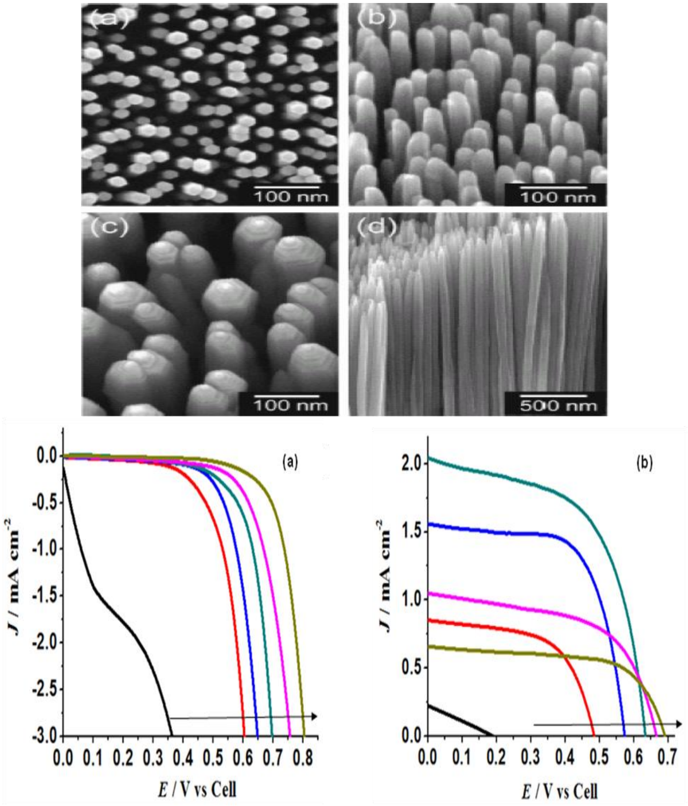

Fig. 1 SEM images of the TiO_2 nanorod arrays (Top). Current density *J* plotted against potential *E* or *V*oc at arrays (Right) coated with organosilane in: 0 (black), 1 (red), 2 (blue), 3 (cyan), 4 (magenta), and 5 (yellow) cycles of coating under the illumination of one sun (panel a) and in the dark (panel b).

Enhancing Conversion Efficiency of Dye-Sensitized Solar Cells by Synthesis of Highly Ordered Titania Structures and Judicious Selection of Redox Couples

Figure 2a and 2b revealed that both the open-circuit voltage (V_{oc}) and the maintenance of the voltage values (lifetimes of photoelectrons and holes) are improved with the number of organosliane coatings, respectively. We found that the overall efficiency of the cell is the best when the number of coatings is three. We have obtained an efficiency that is more than twice of that in a recent report using the same ferrocene/ferrocenium redox couple. By selecting a better redox couple and using a rigorous surface treatment, we expect to further improve the DSSC performance and efficiency.

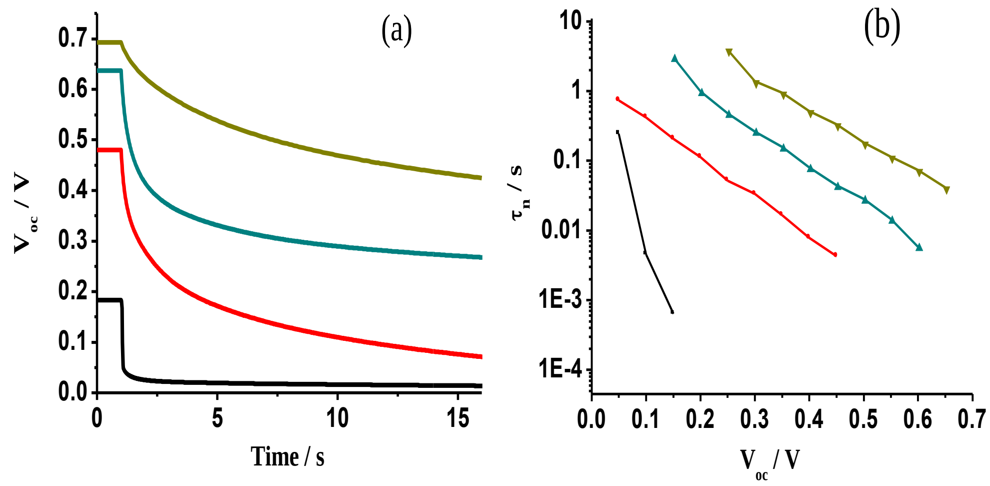

Fig. 2 (a) Open-circuit voltage decay and (b) lifetimes of photoelectrons and holes using electrodes of TiO_2 nanorods coated with organosilane molecules upon 0 (black), 1 (red), 3 (cyan), and 5 (yellow) cycles of coatings.

Table 1. Representative parameters of our DSSCs

Coating times	J_{sc} (mA/cm2)	V_{oc} (Volt)	Fill Factor	Efficiency(%)
0	0.224	0.190	0.263	0.011
1	0.852	0.486	0.587	0.243
2	1.559	0.573	0.658	0.588
3	***2.043***	***0.634***	***0.578***	***0.749***
4	1.049	0.660	0.572	0.396
5	0.660	0.690	0.634	0.289