Conclusions
DSSCs are photoelectrochemical solar devices, currently subject of intense research in the framework of renewable energies as a low-cost photovoltaic device. Their functioning is based on the interlacing of subsystems working in tandem: the photoanode on which the dye sensitizer is adsorbed, the electron mediator and the counter electrode. In this chapter we have tried to give an overview on the recent advances in the design of these solar cell components.

Research on dye sensitizers are mainly focused on transition metal complexes, but a considerable of work is now directed towards the optimization of organic sensitizers and of natural sensitizers extracted from fruits.

Concerning the electron mediators, iodide/iodine has been so far the most efficient and commonly used redox system, due to the fact that I allows for a fast regeneration of the oxidized dye. The use of alternative redox couples as electron mediators has been addressed, so far, by a limited number of research groups but the results are promising. The research has been triggered by the fact that the electrochemical properties of coordination compounds can be easily tuned through a rational choice of the metal and an appropriate design of the coordination sphere and their electrochemical response is sensitive to the electrodic material. The choice and design of the redox couples has been done by considering inexpensive and available metals like the elements of the first transition row and easily synthesizable ligands. To date, the most successful attempts have been based on octahedral cobalt(II) complexes and the best results obtained in combination with specific heteroleptic complexes. The performances of such mediators have been improved by using kinetically fast couples in conjunction with Co(II) complexes. It has been in addition observed that copper complexes with a distorted tetragonal geometry show promise for developing alternative low cost mediators for photoelectrochemical cells.

The transport of the electroactive ions is expected to play a significant role in determining DSSC efficiency: this is particularly true under strong illumination when a large number of photooxidized dye molecules are simultaneously generated at the photoanode ad an efficient turnover of electron donating species is required to sustain the photocurrent. Cell and TiO₂ engineering are therefore required to avoid or reduce the mass transport limitations in DSSCs based on coordination compounds as redox mediators: minimizing the spacing between the electrodes, choosing low viscosity solvents and changing the morphology of the
TiO$_2$ substrate with ordered nanostructures with large pore size or with TiO$_2$ nanotubes and nanorods, expected to enhance mediator transport and cell efficiency.

The search for suitable solid materials that can replace the liquid electrolyte is an additional interesting and active area of research. In a solid state DSSC the solid hole conducting material captures the holes and closes the circuit with the counter electrode. Solid hole conductors include conducting polymers, organic hole conductors and inorganic semiconductors such as CuI and CuSCN. Organic hole conductors like spiro-compounds and conductive polymers based on polythiophenes and polypyrroles have demonstrated some promise for application in dye sensitized solar cells. In particular it has been reported that the presence of ionic liquids may improve the charge transporting capabilities of the heterointerface through screening of space charge effects.

In the last part of the chapter we have described some efforts towards the modification of the counter electrode with inexpensive and transparent materials. The interest being also related to the possible realization of stacked cells, either serially or in parallel connected, in which two spectrally complementary dyes can work in their optimal absorption region, improving the spectral responsivity of the modules. In these studies it has been found that osmium complexes as well as electrodeposited conductive polymers like PEDOP and PEDOT are effective in promoting the electrochemical response of Co(II) electron mediators.

The development of efficient and non corrosive electron mediators is considered of particular relevance since it may allow the building large area modules where the different components are in parallel interconnected, increasing the single module short circuit photocurrent and allowing for a more flexible and solar panel production.