Dye sensitized solar cells: toward a low cost, industrial viable, photovoltaics

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Photovoltaic energy research is experiencing a renewed interest mainly due to the strong request for renewable energy sources. New technologies are now available to improve the photovoltaic conversion efficiencies and to reduce system costs. Standard semiconductor technologies provides good performances but can be expensive, both in terms of production and environmental issues. In order to reduce fabrication costs and to add additional properties to photovoltaic sources, solar cells with organic materials have been realized in both academic and industrial laboratories. Among all the organic and hybrid organic-inorganic solar cells, dye sensitized solar cells (DSC) have demonstrated the highest conversion efficiencies. Compared to traditional photovoltaics, DSC has many advantages, namely low dependence on angle of light, stable operating voltage in all light conditions, good temperature stability, natural colours, optional transparency, very low embodied energy, aesthetically pleasing, low cost of facilitisation. All these characteristic make DSC very appealing for building integration photovoltaics (BIPV)
In this presentation we will review the recent developments of DSC at the Centre for Hybrid and Organic Solar Energy (CHOSE) which has been recently established with the support of Lazio Region, to perform research, development and industrialization of organic and hybrid organic-inorganic photovoltaic technologies.

Figure: An example of DSC cell with a pattern.

In particular, we will show a comparison between device fabricated with different materials and technologies. Concerning materials we have made a systematic study of synthetic (Ruthenium based) and natural based dyes with different mediators ranging from Iodine or cobalt based electrolytes to ionic liquids. Modules has been realized by using both W and Z type technologies and a comparison between them will be discussed. Outdoor measurement of DSC have been made and a discussion of their lifetime will be presented. Experimental activities are supported by proper simulation studies. We developed a finite element method code, within the TiberCAD software, to analyze and simulate the functioning of the whole DSC cell, taking in count the photo-generation of electrons, the loss at the semiconductor and electrolyte interface and the distribution of charge densities (electrons, redox pair and cations) inside the cell. The model implemented is a drift-diffusion where the charge transfer at the cathode is modelized by a Butler-Volmer equation.
In the final part of the talk we will discuss industrial potentialities of DSC technologies that have been recently witness by the agreement signed by two important Italian Industrial companies, ERG Renew and Permasteelisa, Dyesol Italia (Dyesol group Australia) and the Universities of Rome “Tor Vergata” (CHOSE) , Ferrara and Torino to develop BIPV based on dye-sensitised solar cells.