Chapter 65

Quantum Dots Searching for Bondots: Towards Sustainable Sensitized Solar Cells

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ABSTRACT

The relatively new technique of quantum-dots sensitizing the solar cells for optimum cost-efficiency of photovoltaics is reviewed while launching new concept of bonding-quantum dots – the so called bondots (abbreviated as D), founded on the Dirac quantum theory of coupling spinors, while the associated analytics and basic illustration on paradigmatic chemical bonds are revealed, so paving the way for experimentally searching of at least doubling the photo-electric conversion in sustainable bondotic sensitized solar cells.

Motto: We do not inherit the Earth from our ancestors…we are borrowing it from our children!

DOI: 10.4018/978-1-5225-1671-2.ch065
INTRODUCTION

Renewable and sustainable technology is the main and the aim in the XXI\textsuperscript{th} century; this not only because of the economic research, but also for maintaining the global balance between ecosystems and society, including social and global peace, threatened otherwise by a higher and higher energetic demand, by increasing the population number while decreasing the natural resources (Service 1996). On the other hand, physics and chemistry successfully combined their fundamental principles in what was established as nanoscience, immediately turned into nanotechnology by algorithmic contributions and engineering implementations. This way, what is naturally treated as water, earth, air and fire, and their traces in entropic activity/interaction, are converted in the terms of renewability, conversion, and sustainability (Putz & Mirica, 2016). Precisely, the fire appears as light and seems to be less affected from industrial or home pollution process, this way presenting the highest degree of renewability, conversion, and sustainability, to be handle by nanoscience and nanotechnology. Moreover, this way the phenomenological, conceptual and applicative connections between the electromagnetic radiation/solar radiation (photons-bosons) and the structure mater by electrons (fermions) constitute the most important interaction of which control can assure the sustainable future of the humankind (Markvart, 2005).

In this context, the photo-electro-chemical phenomena is already placed in its third century of study and in the third generation of accomplishment (see Figure 1) and application. Regarding its discovering: it started in 1839 with Becquerel communication about photo-potential/ photo-voltage observed at an electrode under the light influence in electrolytic bath/solution; similar effects were noted also in 1870 and 1900 with solid selenium as electrolytic material, though with a conversion/efficiency effect of about 1%; only after another 50 years Daryl Chapin raised the photo-electro efficiency up-to 6% with a silicon cell, with further increasing to 14% and then to 30% for GaAs multi-junction; this way, the inorganic photovoltaic cells era was opened with 20\textsuperscript{th} century applications in satellites implants (starting with Vanguard I in March, 1958), as well as in security developing. Still, these cells proved to be very expensive in fabrication and with a relative fragility (Messenger & Ventre 2004).

This way, the second generation of solar cells were projected based on organic materials, especially conjugated polymers and semiconductors which proved to be promising because of the fast opto-electronic response for the charges carried on the donor-acceptor interface, as well as by adjustment/tunning of the HOMO-LUMO bands even by organic synthesis (Figure 2); the increased control of integrability in plastic and hybrid instruments/objects (functionalized, let’s say, with fullerenes) from daily activities was accordingly accomplished a (Gűnes et al. 2007; Thompson & Fréchet, 2008), along lower fabrication costs for manufacturing on large industrial scale (Sun & Sariciftci 2005). In this stage the study of the so called dye-sensitized solar cell was also possible, generically named as DSSC systems. On the other hand, these cells featured low efficiency to photovoltaic conversion; this state-of-art was until the Grätzel idea/cell developed on the decade 1991-2002’s: the TiO\textsubscript{2} nanocrystals were considered deposited as thin films on the electrode with the complex bipyridil-Ru so achieving the photovoltaic conversion of 10% for a solar non-vertical incidence with air mass AM=1.5 (Grätzel, 2001).

With this conceptual and applicative step the entrance in the third era of photovoltaic systems was practically made, precisely by considering quantum dots type sensitizers, as attached to SnO\textsubscript{2}, ZnO, In\textsubscript{2}O\textsubscript{3}, NiO, Nb\textsubscript{O}\textsubscript{2} oxides and to SnO\textsubscript{2}/ZnO, SnO\textsubscript{2}/MgO, etc. in combined nanostructures (Bang & Kamat, 2009). These new materials with noticeable photoelectrical properties fully use the quantum attributes, i.e. having their dimensions corresponding to a range of energetic action equivalent with their HOMO-LUMO energetic band (donor-acceptor) at their turn corresponding to the nowadays challenge.