Molecular Photovoltaics and Mesoscopic Solar Cells (Paracelsus Award Lecture 2016)

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Mesoscopic photovoltaics have emerged as credible contenders to conventional p-n junction photovoltaics [1-3]. Mimicking light harvesting and charge carrier generation in natural photosynthesis, dye sensitized solar cells (DSCs) were the first to use three-dimensional nanocrystalline junctions for solar electricity production, reaching currently a power conversion efficiency (PCE) of over 14% in standard air mass 1.5 sunlight. Remarquably the PCE increase to 26% in ambient light matching the performance of GaAs photovoltaics. By now, large-scale DSC production and commercial sales have been launched on the multi-megawatt scale for application in building integrated PV and light weight flexible power sources. Recently, the DSC has engendered the meteoric rise of perovskite solar cells (PSCs) [4,5]. Today’s state of the art devices employ metal halide perovskite of the general composition ABX3 as light harvesters, where A stands for methylammonium, formamidinium or caesium, B denotes lead or tin and X iodide or bromide. Carrier diffusion lengths in the 100 nm - micron range have been measured for solution-processed perovskites and certified power conversion efficiencies (PCEs) attain 22%, exceeding the PCE of polycrystalline silicon solar cells. These photovoltaics show intense electro-luminesence matching the external quantum efficiency of silicon solar cells. and Voc values close to 1.2 V for a 1.55 eV band gap material. This renders perovskite-based photosystem very attractive for applications in tandem cells and for the generation of fuels from sunlight mimicking natural photosynthesis [6,7].

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