Industrially-viable Nanotechnology Research Activities: An Overview of Solar Energy Conversion and Greener Hydrogen Energy Generation

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The research of my group at the University of Peradeniya, Sri Lanka, spans a horizon of R&D activities, in the Broad Area of Nanoscience and Nanotechnology. My presentation today is based on our work on nanomaterials in Solar Energy Conversion and Hydrogen Energy Generation, the development of transparent conducting oxide nanomaterials, the Conversion of Local Minerals into Highly Value-added Nanomaterials, and the development of Novel and Low-cost Electrocatalysts for Oxygen Reduction Half-reaction of Fuel Cells.

We have developed transparent Dye-sensitized Solar Cells (DSCs), Low-cost Counter Electrodes based on Non-Platinum Catalysts, Perovskites-sensitized Extremely Thin Absorber Solar Cells, Photon Upconversion as a means to Harvest Infrared Radiation, Clay-polymer-based extremely low-cost oxygen reduction electrodes for use in fuel cells and nanotechnologically engineered catalysts for fast and efficient water photosplitting. In developing DSCs, we have designed, developed and manufactured a novel spray pyrolysis apparatus known as Atomized Spray Pyrolysis where we have introduced an atomizer containing a Teflon spherule onto which the aerosol stream withdrawn are bombarded so as to separate any aggregated particles and hence only the discrete particles to be deposited on the heated substrate attached to the pyrolysis chamber. This instrument was used to fabricate various types of thin films, and the DSCs developed are transparent and give significant efficiencies. Such DSCs can be printed on window panes of houses or vehicles for solar energy conversion while allowing some visible light to pass through them.

We have been pioneered the development of extremely low-cost, clay-polymer based electrocatalysts that are comparable to prohibitively expensive Pt-Rh based electrocatalysts for oxygen reduction that could be used to replace them in fuel cells to realize environmentally friendly power generation for motor vehicles and for remote areas where there is no access to the national grid.

In order to generate hydrogen and oxygen gases required for fuel cell applications, we have developed a TiO_2 /Ag (0) /Nb (V) catalyst which is visible light active and is also capable of upconverting infrared photons to visible photons for use in water photo-splitting. This catalyst when added to distilled water efficiently generates H_2/O_2 mixture at the fastest rate so far achieved. The long nanowire structure of TiO_2, surface plasmon absorption of Ag quantum dots in the visible range and photon Upconversion by the ladder of virtual electronic energy levels introduced by Nb (V) doping are collectively responsible for the superior performance of this catalyst. With these developments cleaner and greener energy production would not be too far and we believe our work could contribute to the development of better and greener cars in the near future.