Transition Metal Oxide Nano composites and 2D@TMO Nano structures for Photoelectrochemical water splitting

Introduction:

Extensive usage of fossil fuels, raising demand for energy by ever increasing population and living standard cause severe climate change to our planet. This urges to go for the production, storage and utilization of green and renewable energy sources. Solar power is abundant in our planet and but meagrely utilized. One of the ways to protect our planet from climate change is to harness solar energy to meet our energy demands. Solar energy is clean energy source and renewable in nature. Converting solar energy into electrical and chemical energy can fulfil our demands. Solar photovoltaic technology is promising for converting solar energy into electrical energy. Generation of fuel based on solar energy is need of the hour for the sustainability of our planet. Recently, tremendous interest has been paid for converting the solar energy into storable hydrogen fuel. The process of solar hydrogen fuel generation can be realized by inspiration from nature: photosynthesis process in which solar energy has been converted into chemical energy by water splitting and producing oxygen and hydrogen. Among the several methods such as direct thermal, thermochemical, photochemical and photoelectrochemical (PEC) methods for water splitting, PEC is the most promising approach for converting solar energy to storable hydrogen energy fuel. PEC of water splitting demands the class of materials with certain properties [1-2].,

- (i) Band gap which enables to absorb visible wavelength region,
- (ii) Valence band and conduction band should straddle on the water redox potentials and
- (iii) Separation of photogenerated electron and hole pairs by avoiding recombination to initiate hydrogen and oxygen evolution.

State of Art:

Solar water splitting is a promising strategy for sustainable production of renewable hydrogen, and solving the crisis of energy and environment in the world. However, large-scale application of this method is hampered by the efficiency and the expense of the solar water splitting systems. Aim of the proposed work is to explore non-toxic, low-cost, efficient and stable photocatalysts for solar water splitting. The ultrahigh surface area and unconventional physiochemical, electronic and optical properties of Two dimensional 2D Transition metal oxide TMO nanocomposites have been demonstrated to facilitate photocatalytic applications. In the form of 2D-TMO nanocomposites, band gap can be altered and recombination of electron hole pairs can be avoided and it will enhance the efficiency. [3-10]

The proposal mainly focuses on preparing different structures of TMOs like 2D and core shell structures by simple wet chemical methods for Photocatalytic and Photo-electrocatalytic applications.

Objectives:

- The research mainly focuses on developing different TMO nanocomposites for photocatalysis.
- To study the photocatalytic behaviour of different TMO nanocomposites.
- To synthesis different 2D@TMO nanocomposites by simple wet chemical methods.
- To improve the photocatalytic behaviour by forming 2D@TMOs Core-shells, 2D-TMOs composites, elemental doping, surface functionalization and hetero junction formation, etc.
- Prepared samples will be characterized by XPS, UV-Vis, XRD to analyse the photoelectrocatalytic properties.

Methodology and workplan:

The main aim of my research is to develop the different 2D-TMO composites to achieving the high efficiency in photoelectrochemical water splitting, for practice here are some materials already reported [3-10].

Synthesis of TMO/rGO Nanocomposite, 2D X@C core-shell structures, X@TiO2-Y/rGO nanoparticles. X= Fe_2O_3, Fe_3O_4, V_2O_5, CoO, $CoFe_2O_4$, Y= Ni, Co, Zn. Using simple wet chemical synthesis.

Synthesis of TMO/rGO Nanocomposites:

- Graphene oxide (GO) will be prepared by slightly modified Hummers method and GO thermally reduced to rGO.
- TMO/rGO Nanocomposites like Fe_2O_3@rGO and CoO@rGO can be synthesised simply by solvothermal treatment using Teflon beaker and stainless-steel autoclave. [3]

Synthesis of 2D Fe_3O_4@C core-shell structures:

- The Fe_2O_3 Nano sheets (NS) can be synthesized using a hydrothermal method.
- Fe_3O_4@C core-shell NSs will be formed by Annealing at 500°C. [4]

Characterization techniques:

Morphologies of the prepared sample will be observed using transmission electron microscopy (TEM), Element analysis will be performed by scanning electron microscopy (SEM) with Energy Dispersive X-Ray Analysis (EDX), Optical properties can be reviled by UV-visible and photoluminescence (PL) spectroscopy, Crystal structure can be found from X-ray diffraction (XRD), Electronic, Physical and chemical properties, and the overall electronic structure will be known from X-ray photoelectron spectroscopy (XPS).

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