Bismuth oxyhalides assisted with silver sulfide based asymmetric or multimeric nanoparticles

Climate change is one of the most challenging problem for humankind nowadays due to the dependence of all energy demand on fossil fuels. Almost every modern economies have been built around fossil fuels and related technologies. It is crucial to find some alternative to fossil fuels for preventing climate change to keep our planet's natural balance. Hydrogen is one of the most important alternative and environmental friendly fuel to fossil fuels because basically when it is combusted, it only releases water and energy. Therefore, there are currently many ways developed to produce hydrogen fuel. Ironically, a great majority of the hydrogen market relies on fossil fuels. Yet another method is splitting water into oxygen and hydrogen using photocatalysis processes which has been widely investigated by scientific communities. In brief, the method is based on light excitation of photocatalyst material to activate it for inducing required reactions to obtain hydrogen gas from water. One of the most popular photocatalyst is TiO_2, but it can be activated by only high energy UV light which is only 5% of solar radiation reaching Earth. Therefore, it is important to develop novel photocatalyst which requires lower energy. In other words, it can be activated by visible light that constitutes the large part of solar spectrum. That can lead the way open for clean and cost effective generation of H_2 fuel.

Two-faced nanoparticles so called "Janus nanoparticles" which get its name from dual face Roman god Janus are of the candidate for photogenerated hydrogen generation. Two constituent material in one material have promising property called localized surface plasmon resonance which deriving from the interacted region of two materials in Janus particles especially considered in metal-semiconductor Janus nanoparticles. Thanks to that, local electric nearfields can form that is beneficial for photocatalytic application. This effect also can be expected from metal-semiconductor multimeric nanoparticles in which metals are located on the several part of photocatalyst. Moreover, synergetic effect can be expected from semiconductor-semiconductor Janus nanoparticles which means semiconductors in Janus nanoparticles act differently than their single form. That can result in promising photocatalyst materials. Ag_2S semiconductor-metal JNPs seem very good candidate for photogenerated hydrogen evolution applications for not only their low band gap that means can be activated by visible light irradiation but also their crystal property which allows different metals to grow on it. On the other hand, bismuth oxyhalides, BiOX (X= Cl, Br, I) are another photocatalyst which was mostly researched for photocatalytic degradation of photocatalytic pollutants which has different reaction mechanism compare to photocatalytic hydrogen evolution. However, they can be manipulated to be applied for hydrogen generation applications by changing their stoichiometry or synthesis methods. That means tunability of bismuth oxyhalides enables to get wide range of these materials and combinations with different photocatalytic properties. Therefore, in this project Ag_2S - Au, Pt, Ag, Ir and in addition Ag_2S-$AgInS_2$ Janus or multimeric nanoparticles will be obtained and combined with larger bismuth oxyhalides photocatalysts to form visible light active photocatalytic systems for hydrogen generation.

The goal of the project is to synthesize both Janus or multimeric nanoparticles and bismuth oxyhalides. After, Janus or multimeric nanoparticles and bismuth oxyhalides will be combined using several methods including chemical linker absorption or physical adsorption to form Janus nanoparticles-BiOX photocatalytic system. Synthesizing bismuth oxyhalides with different methods will make possible to investigate their property depending on their stoichiometry and synthesis methods. Moreover, different growth of metals (Au, Ag, Ir and Pt) on Ag_2S photocatalysts will be investigated. Finally, all samples will be characterized, XRD will be used to identify the materials crystal structure. Microscopic analysis will be conducted using SEM and TEM to determine their shape, surface and particle size.. BET surface area of BiOX photocatalysts will be investigated before and after the combining with Janus or multimeric nanoparticles. Optical properties will be determined to investigate the behavior of obtained materials under visible or UV light irradiation using UV-vis spectroscopy and photoluminescence test. Finally, BiOX, Janus or multimeric nanoparticles and BiOX-Janus photocatalytic systems' will be tested in hydrogen evolution reaction under UV-vis and visible light irradiation.