Abstract

Hydrogen energy has become very attractive since it has remarkably high energy density in comparison to diesel or gasoline and more importantly it is a zero-emission fuel. Although it can be provided from several sources, the key point is that hydrogen production method should have low-environmental impact. Unfortunately, the hydrogen fuel market heavily relies on steam reforming which requires fossil fuel processing under high pressure and temperature conditions where a greenhouse gas, carbon dioxide, is produced largely. Electrolysis can be considered as an alternative method since it uses electricity to split water to oxygen and hydrogen fuel. However, the same criteria apply to this method for the source of the electricity. In other words, depending on the source of the electricity production such as hydropower, wind, or solar energy input, electrolysis process can be sustainable.

The idea of developing a system that converts solar energy directly to hydrogen fuel could be another way to produce hydrogen fuel from water. Photocatalytic hydrogen evolution permits direct solar conversation on account of the photocatalytically active semiconductor materials. Among various of studied photocatalysts, TiO_2 is prominent owing to its suitable band alignment for photocatalytic hydrogen evolution. Nevertheless, the biggest obstacle is that TiO_2 can be activated only via UV part of the solar spectrum. Thus, there is a massive effort that must be taken to develop a photocatalytic system that can initiate PHE process under wider range of the solar spectrum, specifically visible light spectrum. The candidate photocatalyst also should be cheap and require as low as possible amount of noble metal (usually Pt) or have promising Pt-free photocatalytic hydrogen evolution performance.

In my doctoral dissertation, I investigated the several ways to improve the performance of zinc indium sulfide ($ZnIn_2S_4$) which is one of the most popular photocatalyst in the literature especially for the photocatalytic hydrogen evolution applications under visible light spectrum ($\lambda > 420$ nm). Two different types of $ZnIn_2S_4$ based photocatalytic system were investigated in detail: $ZnIn_2S_4/CuInS_2$ and $BiOCl@ZnIn_2S_4$. For $ZnIn_2S_4/CuInS_2$ photocatalytic systems, the first part was related with the development of $ZnIn_2S_4/CuInS_2$ photocatalytic system via hydrothermal method in the presence of pre-prepared $CuInS_2$ quantum dots. While the second part was on a specific question related with the effect of the aggregation properties on PHE performance of $ZnIn_2S_4$. Lastly, the photocatalytic glycerol reforming for photocatalytic hydrogen evolution was examined over $BiOCl@ZnIn_2S_4$.

This thesis begins with the short information about the published works constituting the thesis which are mentioned in the whole thesis as **P1**, **P2** and **P3**. In the introduction part, The Reader can find concise information about the photocatalytic hydrogen evolution providing a strong background which is useful to understand the published works. After implying the aim of the thesis, the publications (**P1**, **P2** and **P3**) are summarized defining the most important points of each published works followed by the summary of the whole thesis highlighting the suggested outcomes of the thesis and propositions for the further studies. Finally, the publications are given with their supplementary information followed by the scientific achievements at the end of the thesis.