PL-05

Black phosphorus analogue : 0D/2D multi-structures of metal sulfide nanocomposites for high-performance solar-driven photocatalyst

Jin-Hyo Boo[1,2]

[1]*Department of Chemistry, Sungkyunkwan University, Republic of Korea*

[2]*Institute of Basic Science, Sungkyunkwan University, Republic of Korea*

* jhboo@skku.edu

Over the past few decades, research on 2D materials has actually been very advanced and is at the forefront of materials science. In addition to graphene, there are many other 2D materials, but the transition metal chalcogenide (TMDC) is only a typical 2D material which is characterized by a variety of series and easy to control with slightly slower charge mobility. Black phosphorus (BPs) is an intermediate between graphene and TMDC, and is studied as a next-generation 2D material due to the anisotropy caused by the curved honeycomb structure. This composite structured catalyst is designed to have a lower dimension than 2D, and to be combined with each other, so that the band structure can be designed to suit the application and complement each other's disadvantages.

Since BP has proved problematic in the photocatalyst field, due to rapid recombination of electrons and holes. To overcome this, the sulfides such as MoS_2, WS_2, and SnS with the same structure of BP analogue were used to control the bands, implying that this method could be responsible for the increased efficiency. Specifically, SnS can absorb a wide range of visible light because its electron affinity is sufficiently low to generate hydrogen from water and its ionization potential is small. In this study, therefore, we successfully designed and synthesized 0D/2D SnS multi-structures using the hydrothermal method. And we demonstrated that our synthesized 0D/2D SnS multi-structured nanomaterials can be used for more efficient photocatalytic applications for improving in both the chromium hexavalent reduction and organic dye reduction, as well as in the hydrogen evolution photocatalyst.

In addition, we also designed and synthesized CdS/SnS/SnS_2 and SnS/SnS_2 nanocomposites with 0D/2D multi-structures by using hydrothermal and ultra-sonication methods, and found that when the bandgap of SnS is wider than that of bulk materials, the nanocomposite materials showed good performance in hydrogen production of photocatalytic reactions under the visible light condition. Especially, the SnS/SnS_2 acts as an efficient catalyst by developing a p-n heterojunction, facilitating the further transfer of photogenerated electrons from the conduction band (CB) of SnS to the CB of SnS_2. When CdS comes into contact with SnS_2, however, electrons from the CB of SnS2 move to the CB of CdS under the action of the built-in electric field. On the other hand, holes in the valance band (VB) of CdS tend to migrate to the VB of SnS_2, and more tend to migrate to the VB of SnS. As a result, a double charge transfer system is established, which improves the separation of electron-hole pairs with an excellent photocatalytic performance.