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Photo/electro-catalytic activity of ceramics produced by high pressure torsion

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Hydrogen is considered as a clean energy carrier for future application, but production of hydrogen without emitting CO_2 is still challenging. Photocatalytic water splitting is an ideal technique to produce hydrogen, but the efficiency of the technique is still quite low. Electrocatalytic hydrogen production from water splitting by using renewable energy sources (i.e. power to gas conversion) is regarded as a main strategy to store renewable energies in the form of hydrogen gas. Moreover, electrocatalysis is widely used in fell cells and for converting undesirable compounds to useful materials such as conversion of CO_2 to fuels or conversion of oxalic acid to glycolic acid. TiO_2 with the anatase structure is considered as a potential electrocatalyst, but its activity should be improved. In this study, to enhance the cathodic electrocatalytic activity of TiO_2 for hydrogen generation and oxalic acid conversion, a high-pressure TiO_2-II phase was stabilized by high-pressure torsion (HPT) straining. The bandgap reduced and the valence band energy increased with increasing the TiO_2-II fraction. The highest electrocatalytic activity was achieved for an anatase-rich hetrostructure containing TiO_2-II nanograins.

Photocatalysis, an effective and in-expensive process, is a technology for treating toxic and dangerous waste and combination of photochemical process and catalysis. Despite the remarkable features of common photocatalysts (TiO_2, ZnO, Al_2O_3 and MgO), there exist certain associated drawbacks such as faster charge carrier recombination, low photo-induced reaction efficiency and rapid deactivation due to the accumulation of less reactive by-product on the photocatalyst's surface. Narrowing the bandgap of photocatalysts by dopant-free approaches has been in the spotlight in recent years. Theoretical studies suggested that high-pressure phases of some photocatalysts have low bandgaps which can coincide with the visible light. Herein, high-pressure phases of SiO_2 and ZrO_2, expected to have lower bandgap (< 5 eV), will be stabilized by high-pressure torsion method at ambient pressure to enhance the photocatalytic activity and hydrogen generation under ultraviolet (UV) and visible light.