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Highly efficient oxygen-deficient reduced TiO_2-X for sunlight-induced water splitting for H_2 generation

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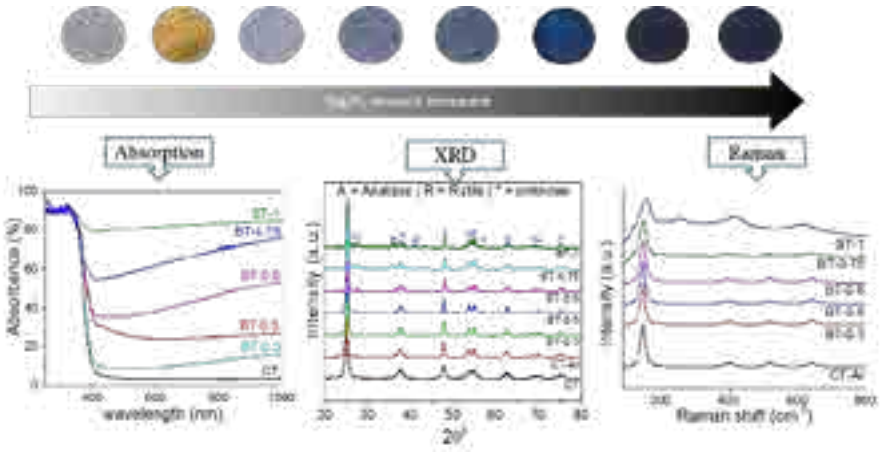
High efficiency with stable performance and utilization of visible light is a key challenge to sunlight-induced photochemical generation of H_2, the cleanest energy carrier. Recently, black TiO_{2-x} materials were achieved by creating oxygen vacancies and/or defects at the surface using different methods. Fascinatingly, they exhibited an extended absorption in VIS and IR as well as UV light, along with a band gap decrease from 3.2 (anatase) to ~1 eV. However, despite the dramatic enhancement of optical absorption of black TiO_{2-x} material, it fails to show expected visible light-assisted water splitting efficiency. Therefore, a new reduced TiO_2 material with optimized properties would be highly desired for visible light photocatalysis. Herein, we report H-doped reduced TiO_{2-x} nanoparticles prepared by a controlled reduction via the simultaneous presence of two active reducing species, [Mg] and [H] in a confined microenvironment at the surface of TiO_2. This new material exhibits outstanding activity (31.4 mmolg-1h-1) and excellent stability after Pt deposition for photochemical H_2 generation from methanol-water in simulated sunlight. The excellent photoactivity of H:TiO_{2-x} is attributed to the oxygen vacancies and H doping at the TiO_2 surface generated by [Mg] and [H]. The photocatalyst works at wavelengths <700 nm and exhibits reasonable visible-light activity with a quantum yield of 17.8, 7.62 and 3.72% at 400, 420 and 454 nm, respectively, along with an exceptionally high turnover number (238680) with respect to Pt. This outstanding activity can be correlated with the extended absorption of visible light, perfect band position, presence of an appropriate amount of Ti^{3+} and oxygen vacancy and slower charge recombination.



Biography

Jong-Sung Yu has earned his BSc in Chemistry from Sogang University in Seoul, South Korea and PhD from the University of Houston in 1990 before Postdoctoral work at Ohio State University. He was a Professor in South Korea University during 2008-2015 and then joined DGIST. Currently, he is a Supervisor for graduate students of Light, Salts and Water Research Lab and a Chairperson at Energy Systems Engineering Department of DGIST, where his research focuses on nanostructured materials, including nanoscale 0-3D materials and their composites and their energy applications for fuel cells, batteries, super-capacitors, sensors and photocatalytic systems.

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