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Carbon (C), Nitrogen (N) and Chromium (Cr) Doped Titanium Dioxide Nanomaterials for Photocatalytic Water Splitting

Gamage UDS¹, Thotawatthage CA¹, Wijewardane HO¹

¹*Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihinthale, Sri Lanka*

Water splitting is a process of breaking down water into hydrogen (H₂) and oxygen (O₂). It is a thermodynamically uphill reaction, with a positive Gibbs free energy change ($\Delta G^\circ = 237 \text{ kJ/mol}$). When incident light with energy higher than the band gap of a semiconductor catalyst is absorbed, it generates electron-hole pairs in the conduction and valence bands. These charge carriers drive redox reactions similar to electrolysis, electrons reduce water to produce H₂, while holes oxidize water to release O₂. Titanium dioxide (TiO₂) is commonly used as a photocatalyst for water splitting, especially under ultraviolet (UV) light. This study focuses on water splitting using doped TiO₂. Factors such as the catalyst material, band gap energy, and type of light source influence the efficiency of the process. Doping TiO₂ with C, N, and Cr helps to reduce the band gap and improve light absorption, thereby enhancing the water splitting reaction. Scanning Electron Microscopy (SEM) images show that the synthesized particles are round and range in size from 1 to 5 micrometers. UV spectra analysis showed an optimal band gap of 1.975 eV. Energy Dispersive X-ray (EDX) analysis revealed the presence of all three dopants, with Cr showing the highest concentration. Fourier-Transform Infrared Spectroscopy (FTIR) identified peaks corresponding to OH groups, CO₂, and Carbon–Carbon vibrational stretching. Synthesized 0.3 g of K₂CrO₄-doped TiO₂ sample demonstrated photocatalytic effect in water splitting activity under sunlight, as evidenced by bubble evolution. However, based on the observed bubble evolution rate, it can be concluded that this material does not exhibit superior performance compared to other reported photocatalysts for solar-driven water splitting.

Keywords: water splitting, doping, band gap, chromium, characterization techniques