**Title :** Study of Nonmetals-doped Titanium Dioxide Nanotubes for Photocatalytic-Hydrogen production and Dye Degradation

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# ABSTRACT

Photocatalysts are a class of catalysts that have attracted considerable attention as materials for alternative energy production and sustainable wastewater treatment, particularly rod-shaped titanium dioxide ($TiO_2$). However, $TiO_2$ still has a major limitation due to its high rate of charge recombination, which reduces its photocatalytic efficiency. Therefore, this study investigated the doping of $TiO_2$ with non-metals, including nitrogen (N), sulfur (S), and fluorine (F), in order to improve its performance and suppress charge recombination. $TiO_2$ was synthesized using a hydrothermal process at 180 °C for 36 hours, followed by calcination at 700 °C for 5 hours. The obtained $TiO_2$ was then ground with the respective non-metal dopants and further calcined at 450 °C for 1 hour. The effects of dopant concentrations at 5, 10, and 20 wt% were systematically studied. The structural and morphological properties of the prepared photocatalysts were characterized using X-ray diffraction (XRD), scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), and X-ray photoelectron spectroscopy (XPS). The results confirmed the successful incorporation of non-metal dopants into $TiO_2$. The catalysts exhibited a rod-like morphology with a rough surface, attributed to the presence of non-metal species on the $TiO_2$ rods. Photocatalytic dye degradation tests showed that $TiO_2$ doped with 5 wt% sulfur (S) achieved the highest degradation efficiency of

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97.21%, while undoped $TiO_2$ showed a degradation efficiency of 94.50%. In hydrogen production experiments, $TiO_2$ doped with 10 wt% fluorine (F) demonstrated the highest hydrogen yield of 9191.90 $\mu$mol/g, whereas undoped $TiO_2$produced 9160.41 $\mu$mol/g under the same reaction time of 2 hours.

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