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Lanthanum Doped Nb_2O_5 Photocatalysts for Synthetic Dye Degradation

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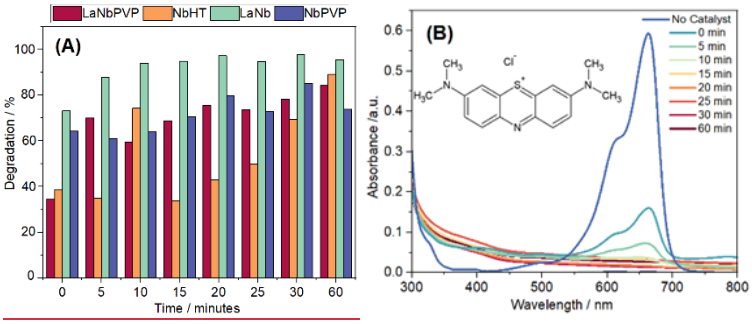
Highlights

Rare earth metal doping significantly enhanced photocatalytical degradation of MB. PVP addition negatively impacted catalyst performance.

Abstract

Industrial wastewater from textile and cosmetic factories poses a pollution risk to aquatic bodies due to inefficient removal of synthetic dyes. The increasing environmental concern has urged the development of cost-effective and robust photocatalysts. Niobium pentoxide (Nb_2O_5), a semiconductor, has gained attention due to its suitable bandgap, high chemical stability, and abundance, making it an attractive material for application in dye degradation. The incorporation of rare earth metals such as lanthanum (La) into the Nb_2O_5 lattice has been investigated as a way to reduce the recombination rate of electron-hole pairs, enhance light absorption, and improve reaction kinetics [1]. In this study, La-Nb_2O_5 catalysts were synthesized hydrothermally (at 180 °C, for 24 h) using lanthanum nitrate and commercial HY-340 Nb_2O_5 with a molar ratio of 0.02:1 (La:Nb). The influence of adding polyvinylpyrrolidone (PVP) to stabilize crystalline structure was also evaluated. Photocatalytic experiments were conducted in a temperature-controlled reactor (30 °C) containing a 5 ppm methylene blue (MB) dye solution under acidic conditions (pH 3) with 1 mL of 30% H_2O_2. The system was stirred in the dark for 30 min to reach adsorption equilibrium, and then irradiated using a UV lantern (λ = 365 nm) for 1 h. Samples collected during the reaction were centrifuged at 4000 rpm for 10 min to remove the catalysts and analyzed using a UV-Vis spectrophotometer. After 1 h of reaction, the catalyst treated with polymer (Nb_2O_5-PVP) exhibited the lowest photocatalytic degradation performance. Both hydrothermally treated Nb_2O_5 (Nb_2O_5-HT) and the doped catalyst with the polymer ($La_{0.04}Nb_{1.96}O_5$-PVP) showed intermediate efficiencies, meanwhile the doped catalyst without polymer ($La_{0,04}Nb_{1,96}O_5$) demonstrated the highest photocatalytic activity. These findings indicate that the La incorporation significantly enhances the photocatalytic efficiency of Nb_2O_5 catalysts, while PVP addition negatively influences their performance in photochemical applications.

Figure 1 – (A) Photocatalytic degradation efficiency of materials. (B) UV-Vis spectra of MB degradation for $La_{0.04}Nb_{1.96}O_5$.



[1] TANVEER, Muhammad *et al.* To study the impact of La and Mo coexistence in pure Nb_2O_5 nanostructure for the improvement of photocatalytic hydrogen production and verification by theoretical analysis. *Materials Chemistry and Physics*, v. 334, 130497, 2025. DOI: 10.1016/j.matchemphys.2025.130497.

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