IOCPC 2026 Conference

The 1st International Online Conference on Photochemistry

8–9 April 2026 | Online

MDPI

High-Performance TiO_2-NiO Nanocomposites for Wastewater Photoremediation

KaiXuan Gan, A. A. Salim*, S. K. Ghoshal, M.S. Aziz, H. Bakhtiar

[a] Physics Department and Laser Centre, ISI-SIR (CsNano), Faculty of Science, Universiti Teknologi Malaysia, 81310 Skudai, Johor Bahru, Malaysia

Email: asali@utm.my*

INTRODUCTION

- Textile dyes (e.g., methylene blue (MB) and methyl orange (MO)) are persistent water pollutants.
- Conventional treatments are inefficient and may generate secondary pollution.
- Photocatalysis offers a green and effective approach for wastewater remediation.
- Pulse laser ablation in liquid (PLAL):
  - Green, surfactant-free synthesis
  - Prodcues high-purity nanomaterials

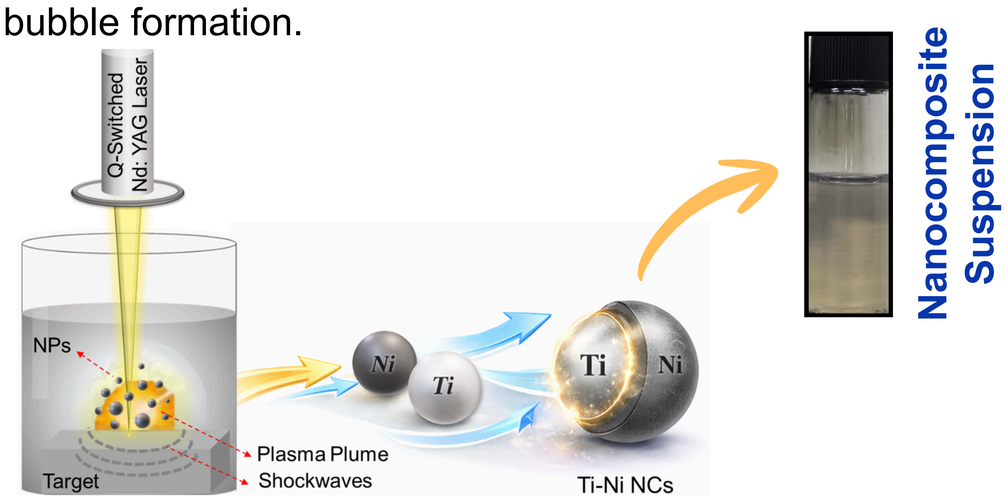
OBJECTIVES

- Develop TiO_2-NiO nanocomposites via the PLAL technique.
- Enhance UV-derived photocatalytic activity.
- Evaluate degradation of MB and MO dyes.
- Investigate charge separation mechanisms.

EXPERIMENTAL WORKFLOW

Synthesis

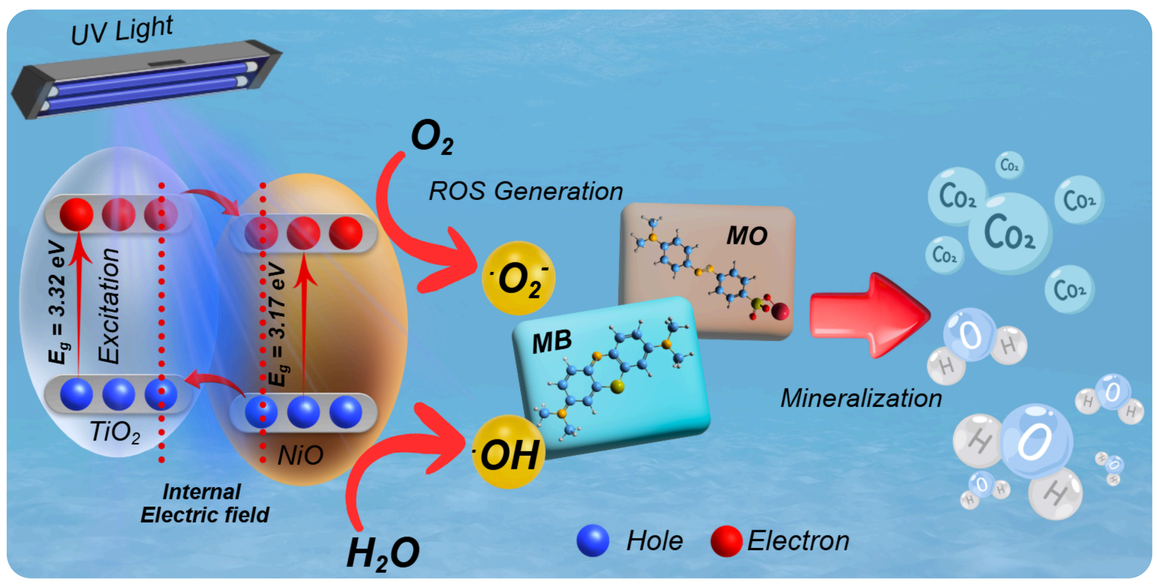
- TiO_2 and NiO NPs were prepared using a nanosecond Q-switched Nd:YAG laser and combined to form TiO_2-NiO NCs.
- The PLAL process involved plasma generation and cavitation bubble formation.



UV-assisted dye degradation

- Photocatalytic activity was assessed by monitoring MB and MO degradation under UV irradiation.

Proposed Photocatalytic Mechanism

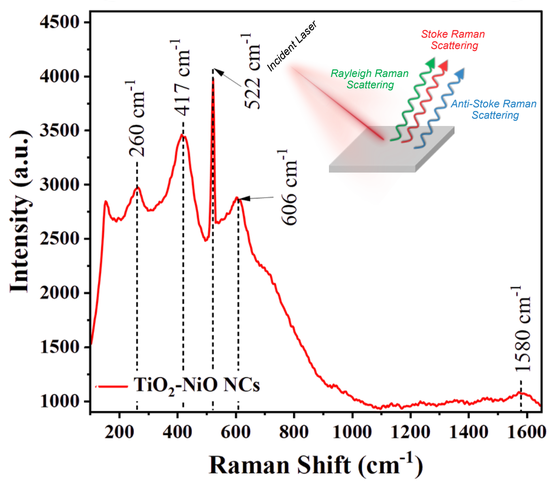


Improved electron-hole separation

Stronger ROS generation and dye mineralization

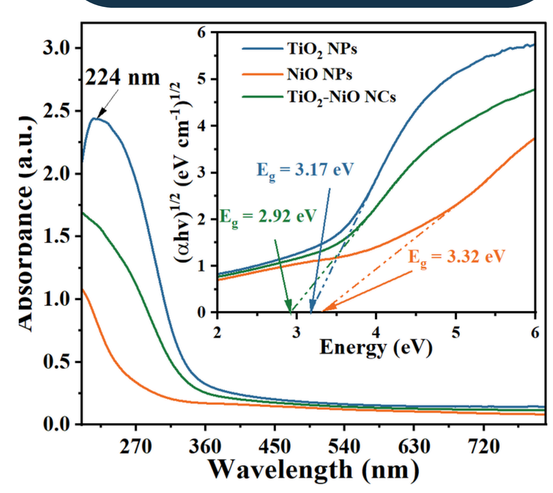
MATERIAL CHARACTERIZATION

Chemical Structure



Raman Spectra of TiO_2–NiO nanocomposites

Optical Properties

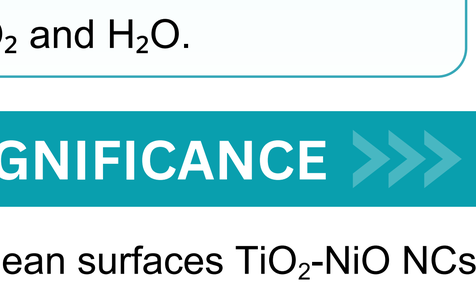


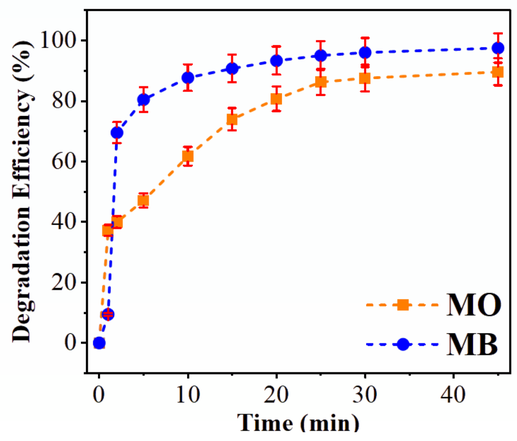
Tauc plots: 2.92 eV for TiO_2–NiO nanocomposites

- Raman revealed the anatase TiO_2 structure in the TiO_2-NiO NCs.
- UV-Vis exhibited enhanced absorption and reduced bandgap (2.92 eV).

PHOTODEGRADATION PERFORMANCE

- Absorbance intensity decreases gradually with irradiation time, indicating effective dye degradation.
- TiO_2-NiO NCs outperform the individual NPs, consistent with faster charge separation and more efficient ROS generation.





97.1%

MB removal under UV

89.6%

MO removal under UV

- UV light activated the TiO_2-NiO photocatalyst.
- ROS such as •OH and •O_2^- accelerated dye oxidation.
- The dyes were mineralised into CO_2 and H_2O.

CONCLUSION AND SIGNIFICANCE

- **Green synthesis:** PLAL produced clean surfaces TiO_2-NiO NCs.
- **Optical enhancement:** Strong UV absorption, reduced band gap (2.92 eV).
- **High photocatalytic efficiency:** MB (97.1%) and MO (89.6%) removal.
- **Impact:** Sustainable, high performance photocatalysts for wastewater remediation.

KEY HIGHLIGHTS

Green PLAL synthesis

Reduce bandgap

High dye-removal efficiency