



Tailoring $\text{CoNb}_{2-x}\text{Mo}_x\text{O}_6$ Columbite Oxides for High-Efficiency Dye Degradation in Wastewater Treatment

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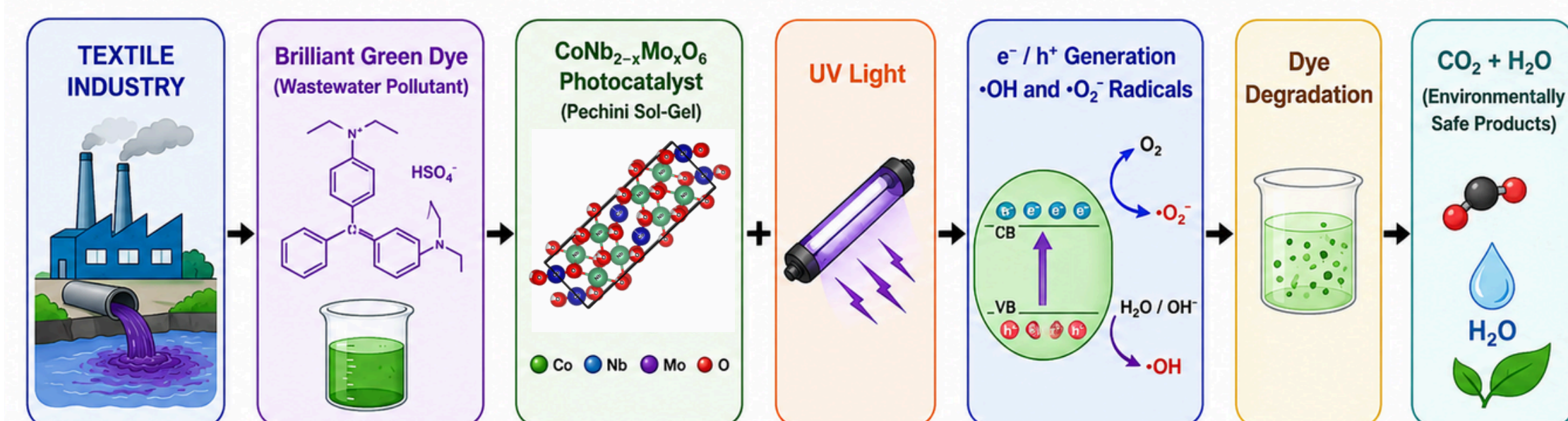
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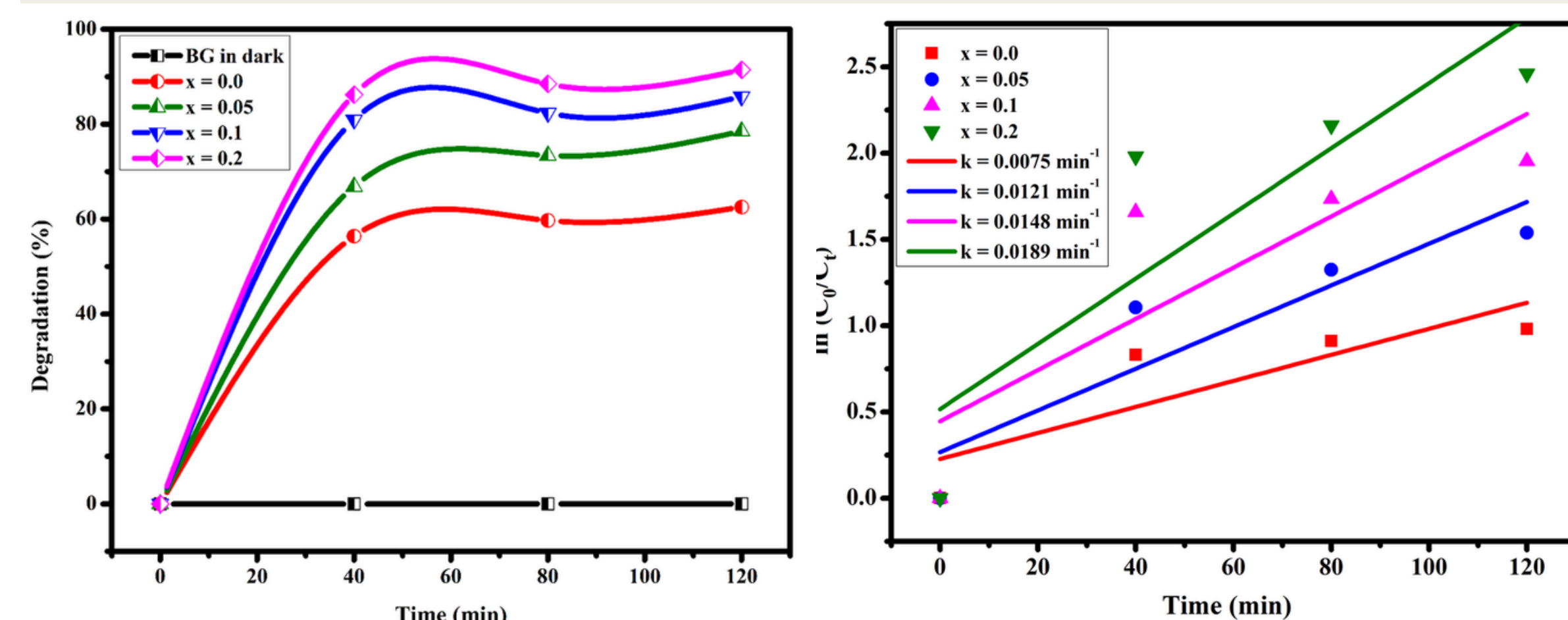
INTRODUCTION

- Dye-contaminated industrial wastewater poses serious environmental and health risks.
- Semiconductor photocatalysis offers a sustainable approach for degrading organic pollutants into harmless products.
- Columbite-type CoNb_2O_6 is a stable photocatalyst, but its wide band gap limits photocatalytic efficiency.
- Mo doping can tune the electronic structure, improve light absorption, and enhance charge-carrier separation.
- This work investigates the effect of Mo substitution on the structural, optical, and photocatalytic properties of $\text{CoNb}_{2-x}\text{Mo}_x\text{O}_6$ for Brilliant Green dye degradation.



PHOTOCATALYSIS

- Photocatalytic degradation efficiency increased with Mo concentration, reaching 91.43% for $\text{CoNb}_{1.80}\text{Mo}_{0.20}\text{O}_6$ after 120 min of UV irradiation.
- Kinetic analysis followed pseudo-first-order behavior, with the rate constant increasing from 0.0075 to 0.0189 min^{-1} .



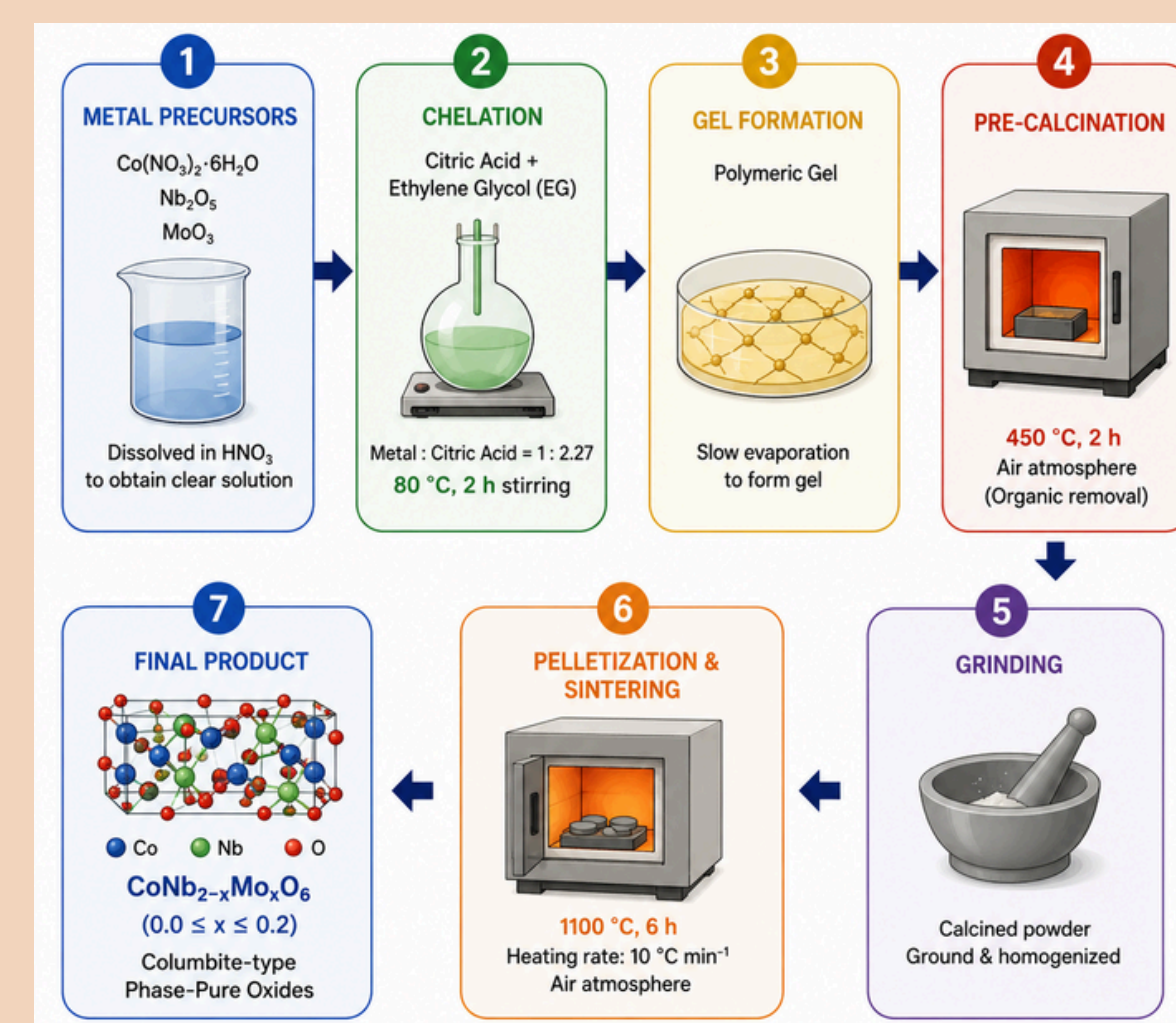
OBJECTIVE

To synthesize and optimize Mo-doped $\text{CoNb}_{2-x}\text{Mo}_x\text{O}_6$ photocatalysts and evaluate the effect of Mo substitution on their structural, optical, and photocatalytic properties for efficient Brilliant Green dye degradation in wastewater.



METHODOLOGY

Pechini Sol-gel method

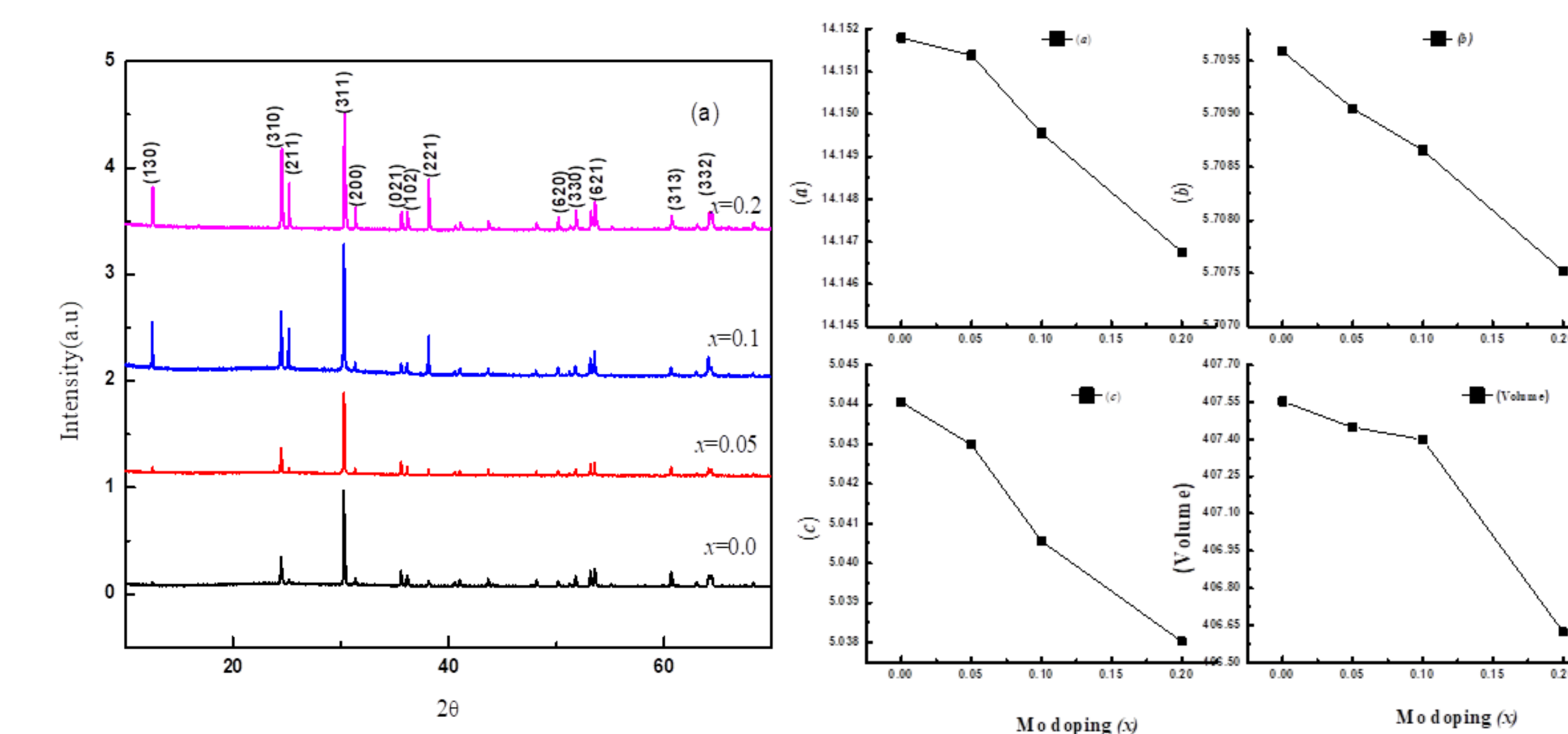


ANALYSIS

- XRD & Rietveld Refinement:** Crystal structure and crystallite size.
- SEM:** Surface morphology and microstructure.
- FTIR:** Metal-oxygen bond verification.
- UV-Vis:** Optical properties and band gap.

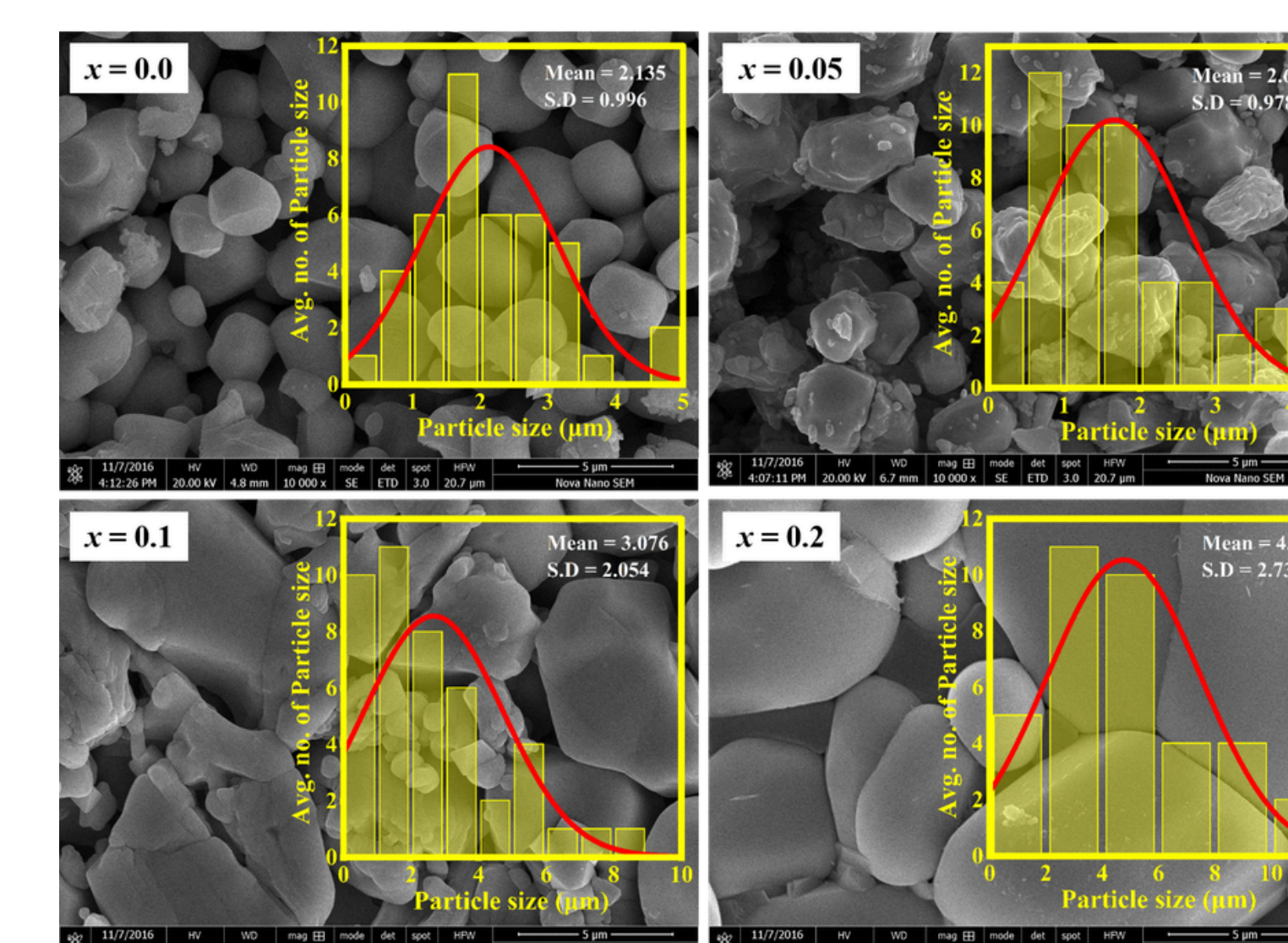
1. XRD & RIETVELD REFINEMENT

- Single-phase orthorhombic structure
- Lattice contraction with Mo doping



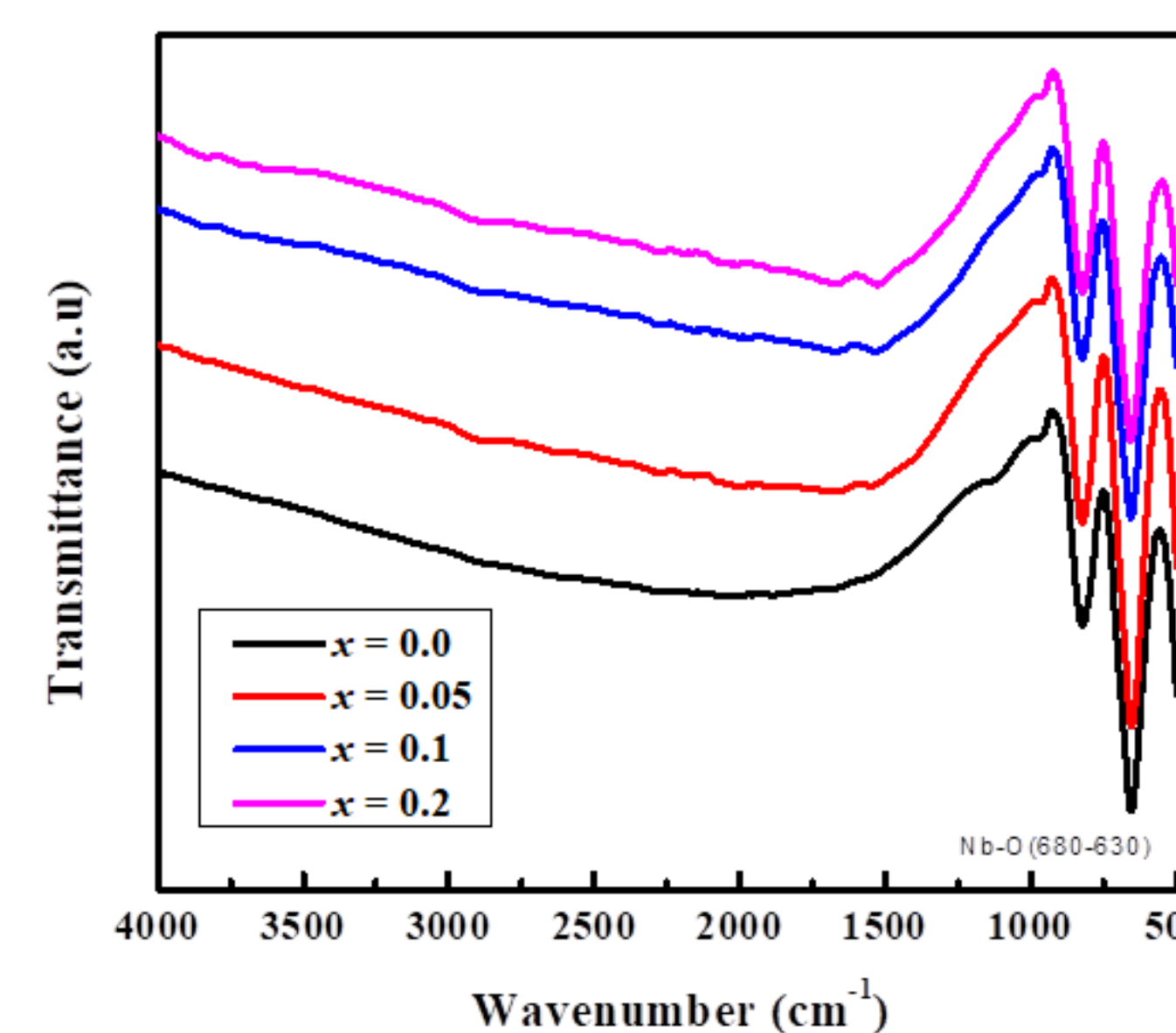
2. SEM ANALYSIS

- Morphological evolution
- Grain growth



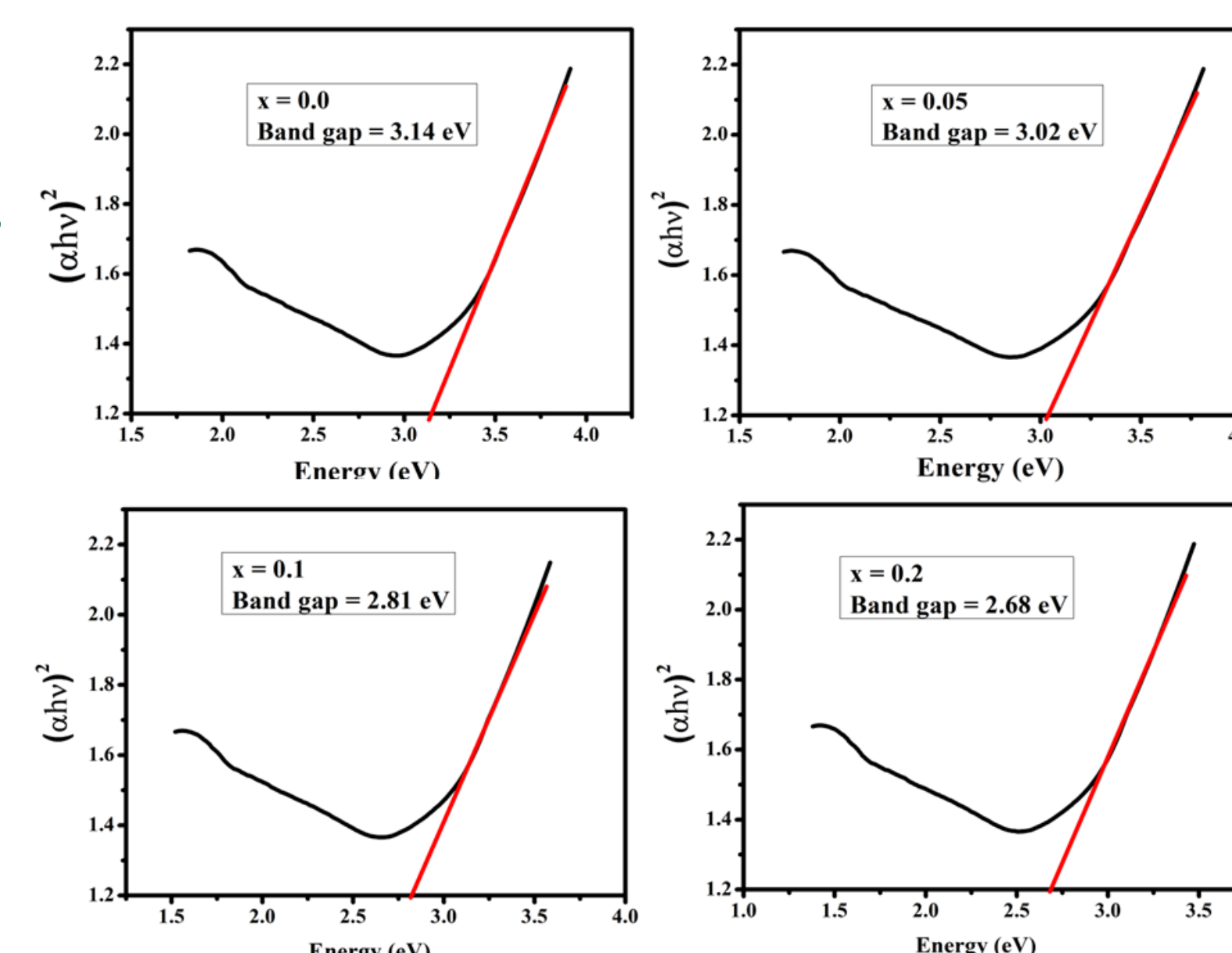
3. FTIR ANALYSIS

- $\text{NbO}_6/\text{MoO}_6$ vibrations
- Structural integrity



4. UV-VIS/TAUC PLOT

- Mo doping progressively reduced the optical band gap from 3.14 eV to 2.68 eV.



RESULTS/FINDINGS

- ✓ Single-phase orthorhombic columbite structure retained.
- ✓ Band gap narrowed: 3.14 → 2.68 eV
- ✓ Enhanced visible-light absorption.
- ✓ Brilliant Green degradation: 62.54% → 91.43%
- ✓ Reaction rate increased: 0.0075 → 0.0189 min^{-1}

CONCLUSION

Mo-doped CoNb_2O_6 emerged as a promising photocatalyst for efficient dye degradation, offering a sustainable pathway for advanced wastewater treatment.

ACKNOWLEDGMENTS

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References

- De, A., M.A. Rambaran, and C.A. Ohlin, Fabrication and Electrocatalytic Evolution of Alkali-Free CoNb_2O_6 Thin Films for Water Oxidation via Polyoxoniobates. *ACS Applied Energy Materials*, 2024. 7(19): p. 8333-8341.
- Ravi, P. and J.S. Noh, Recent Progress and Future Perspectives of MNb_2O_6 Nanomaterials for Photocatalytic Water Splitting. *Materials (Basel)*, 2025. 18(15).