Synthesis, characterization and photocatalytic application of \( \alpha\text{-Fe}_2\text{O}_3 \) nanorod

Jyoti Prakash Dhal, Braja Gopal Mishra and Garudadhwaig Hota*
Department of Chemistry, National Institute of Technology Rourkela, India.

Introduction

- One-dimensional nanostructure such as nanorods, nanotubes, nanowires and nanofiber have attracted much interest due to their combination of superior properties like small dimension, high aspect ratio and unique device function that lead to a large range of promising applications in catalysis, adsorption, electronics, photonics, chemical sensors, field emission devices, solar cells, lithium ion battery, hydrogen storages and drug deliveries.
- \( \alpha\text{-Fe}_2\text{O}_3 \) is a n-type semiconductor with band gap of 2.2 eV and hence it has been extensively used as a solar light photocatalyst.
- In the present work, we reported fabrication of rod like \( \alpha\text{-Fe}_2\text{O}_3 \) by a facile soft chemical route for photocatalytic degradation of Malachite Green from aqueous solution under natural sun light.

Flow chart for synthesis of \( \alpha\text{-Fe}_2\text{O}_3 \) nanorod

A

- Oxalic acid + CTAB + Ethanol

B

- Ferrous sulphate + Water

Displacement reaction

Yellow ppt

Dry at 80°C, 2 hrs

\( \text{FeC}_2\text{O}_4\cdot2\text{H}_2\text{O} \) nanorod

Calcination at 550°C, 2 hrs

\( \alpha\text{-Fe}_2\text{O}_3 \) (Hematite) nanorod

X-Ray diffraction Analysis

- The X-ray diffractograms reveal the well crystalline nature of the compounds.
- The broadening of the peaks also indicates the decrease in the diameter and an increase in the surface to volume ratio of the compounds.

FTIR Analysis

- \( \text{FeC}_2\text{O}_4\cdot2\text{H}_2\text{O} \)


UV-Vis-DRS spectra and Band gap calculation

1. The peaks at 355 nm and 484 nm correspond to 6A1(2) → 2(4E) ligand field transition of Fe\(^{3+}\), respectively. Again, the peak at 537 nm corresponds to fingerprint region of the band edge of hematite. This experiment further confirms the formation of pure \( \alpha\text{-Fe}_2\text{O}_3 \).
2. The energy band gap = 2.04 eV, i.e. the prepared nanorod possesses semiconducting properties with narrow band gap and hence it is a very efficient solar light photocatalyst.

Application for waste water treatment: Photocatalytic degradation of Malachite Green

UV-Vis spectral changes of Malachite Green (\( \lambda_{\text{max}}=618 \) nm) as a function of reaction time

- Photocatalytic degradation of Malachite Green on \( \alpha\text{-Fe}_2\text{O}_3 \) nanorod under solar light irradiation

- The Malachite Green concentration changes under the natural sunlight irradiation over \( \alpha\text{-Fe}_2\text{O}_3 \) nanorod

Conclusions

- We have synthesized \( \alpha\text{-Fe}_2\text{O}_3 \) nanorod by a facile soft chemical method using Ferrous oxalate, oxalic acid and CTAB in a solution of ethanol/water mixture.
- The SEM images indicates fiber like morphology with diameter around 100-200 nm.
- The formation of \( \alpha\text{-Fe}_2\text{O}_3 \) (hematite) phase was confirmed by XRD and FTIR analysis.
- The UV-Vis-DRS spectra shows that the prepared \( \alpha\text{-Fe}_2\text{O}_3 \) nanorod exhibits semiconductor nature and hence can be used as an efficient visible light photocatalyst.
- The Malachite Green decomposition kinetics was studied. It is observed that the Malachite Green was absolutely decomposed by increasing the irradiation time up to 210 min.

Acknowledgements

The authors acknowledged NIT Rourkela for providing the research facilities & funding.

References


*Corresponding Author: garud@nitrkl.ac.in, Contact: +91-9938646340