Synthesis, characterization and photocatalytic application of α-Fe_2O_3 nanorod

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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 structure, 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.
- α-Fe_2O_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 α-Fe_2O_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 α-Fe_2O_3 nanorod

A: Oxalic acid + CTAB + Ethanol

B: Ferrous sulphate + Water

→ Displacement reaction

→ Yellow ppt

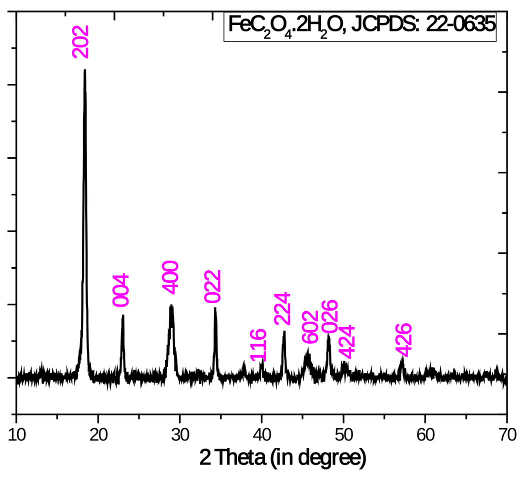
→ Dry at 80°C, 2 hrs

→ $FeC_2O_4.2H_2O$ nanorod

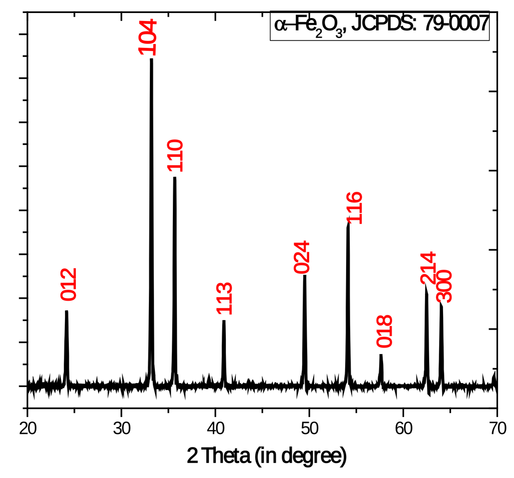
→ Calcination at 550°C, 2 hrs

→ α-Fe_2O_3 (Hematite) nanorod

X-Ray diffraction Analysis



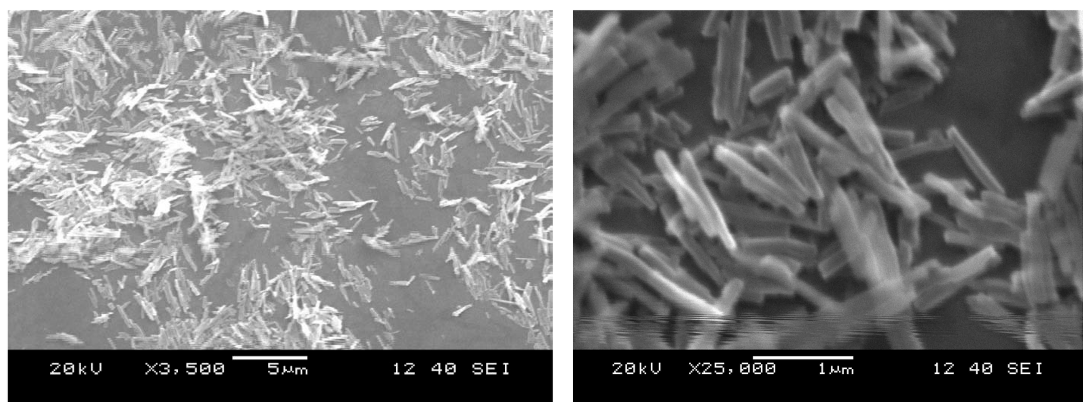
XRD Pattern of $FeC_2O_4.2H_2O$ nanorod



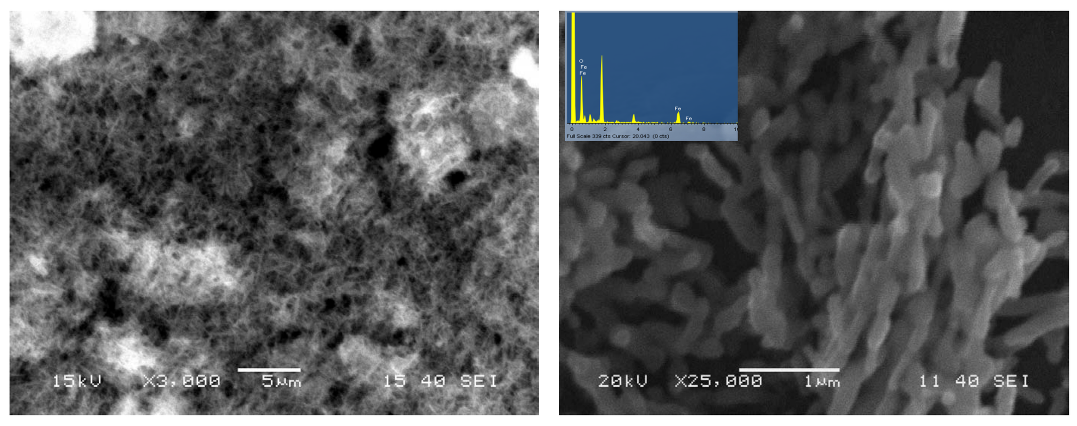
XRD Pattern of α-Fe_2O_3 nanorod

- 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

SEM & EDAX Analysis

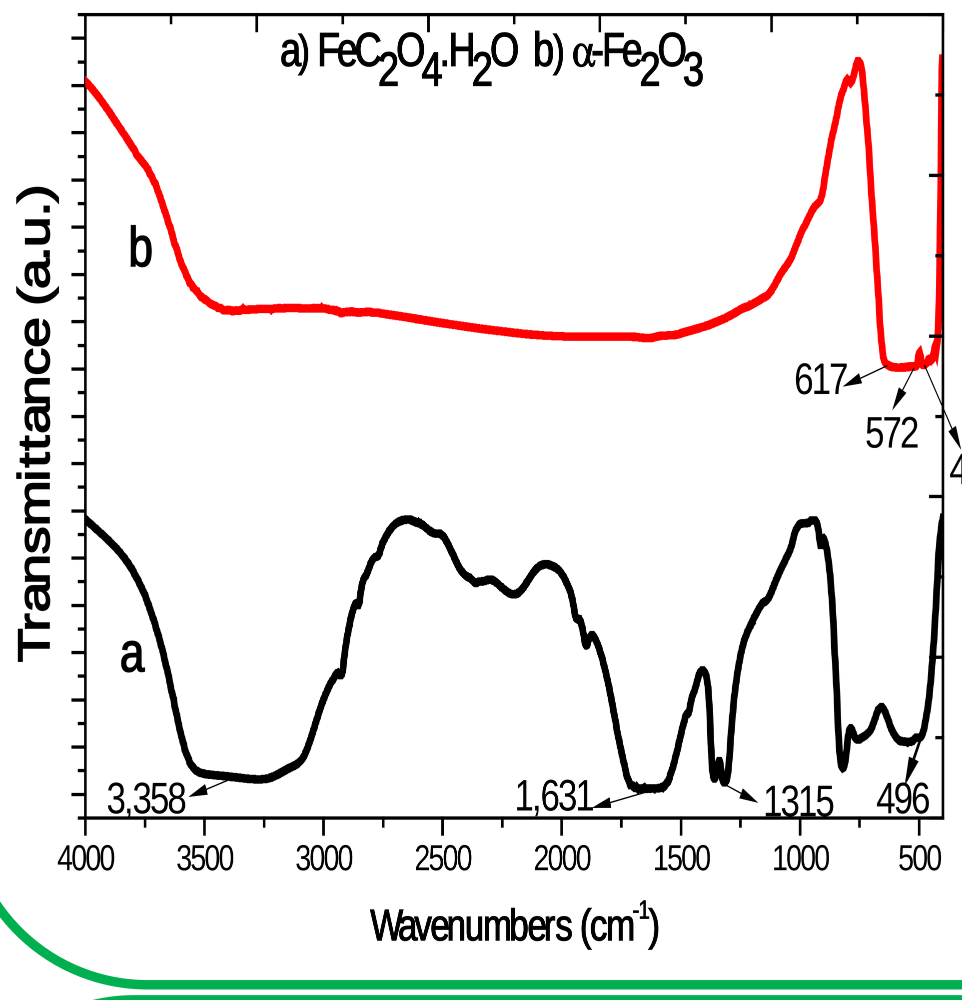


SEM Micrographs of $FeC_2O_4.2H_2O$ nanorod (Low & High Magnification)



SEM Micrographs of α-Fe_2O_3 nanorod (Low & High Magnification) With EDAX (incet)

FTIR Analysis



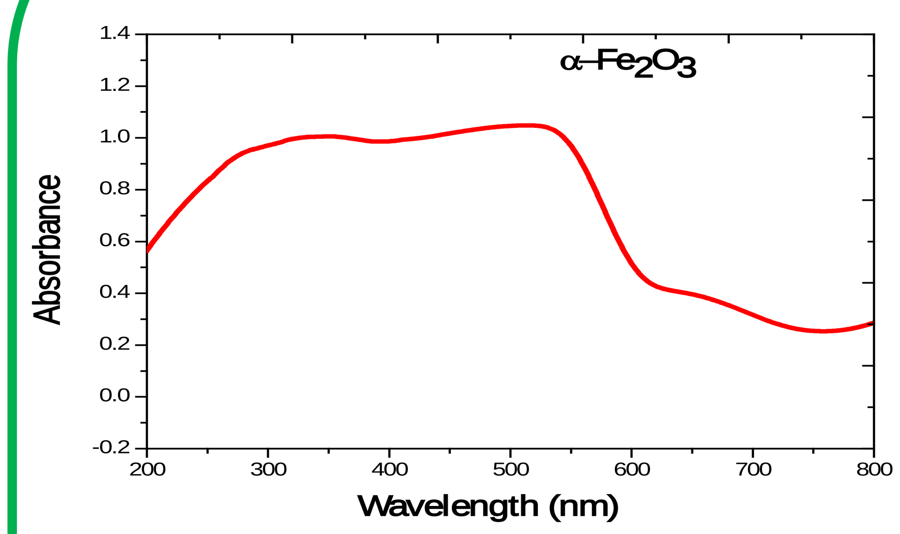
$FeC_2O_4.2H_2O$

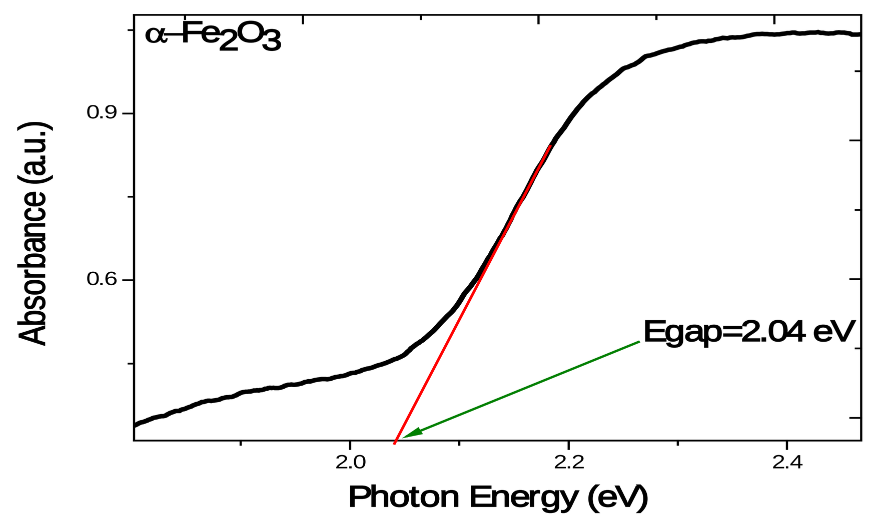
3358: O-H
1629: C=O
1318: C-O
496: Fe-O

α-Fe_2O_3

617: Longitudinal Absorption (Au)
572 & 490: Transverse Absorption (Eu) of Fe-O

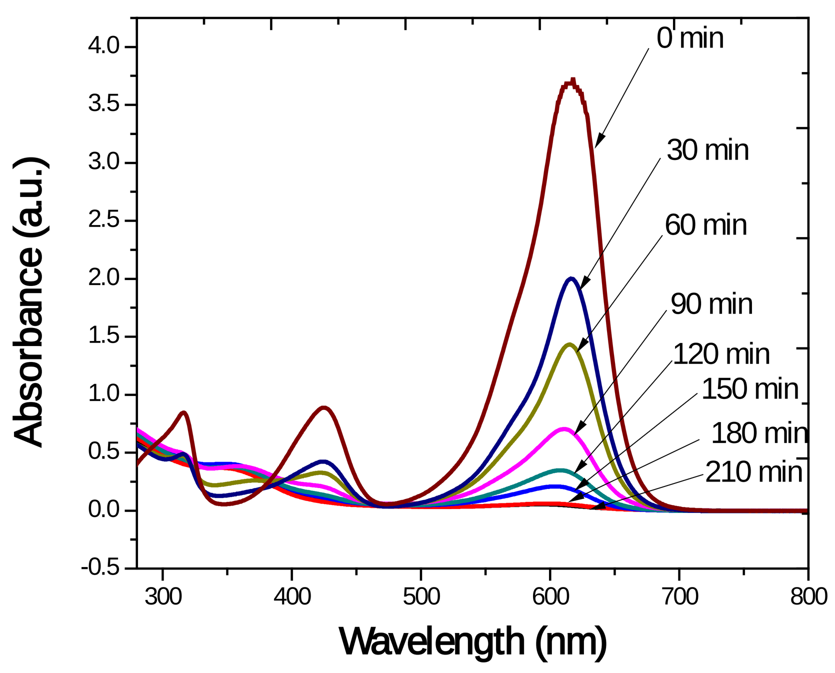
UV-Vis-DRS spectra and Band gap calculation



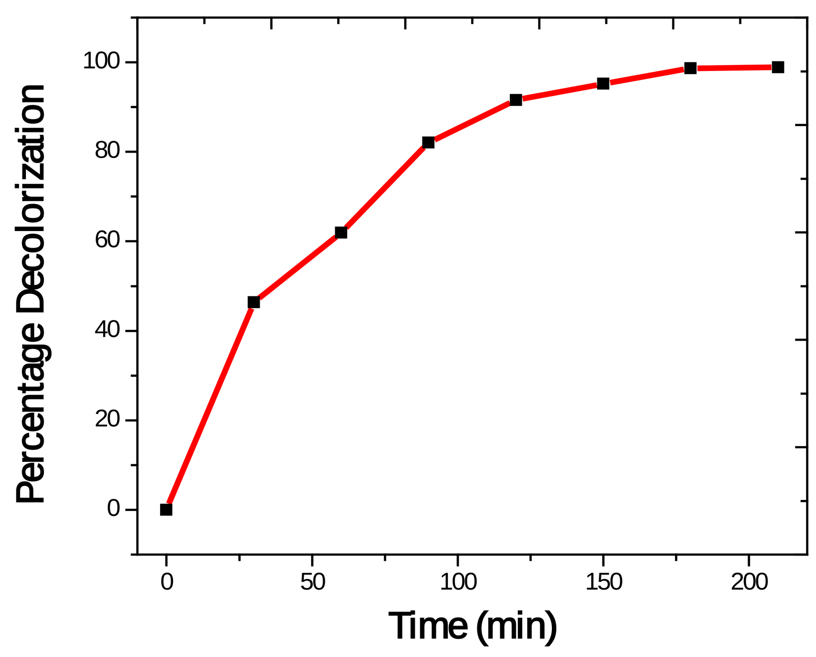


1. The peaks at 355 nm and 484 nm correspond to $^6A_1 \rightarrow {}^4E$ and $2(^6A_1) \rightarrow 2(^4T_1)$ ligand field transition of Fe^{3+}, respectively. Again, the peak at 537 nm corresponds to finger print region of the band edge of hematite. This experiment further confirms the formation of pure α-Fe_2O_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.

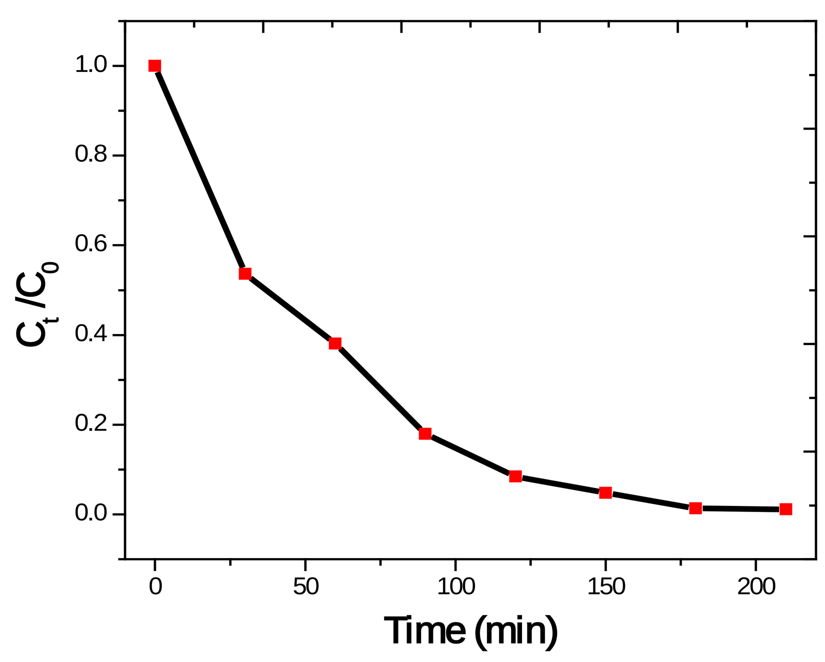
Application for waste water treatment: Photocatalytic degradation of Malachite Green



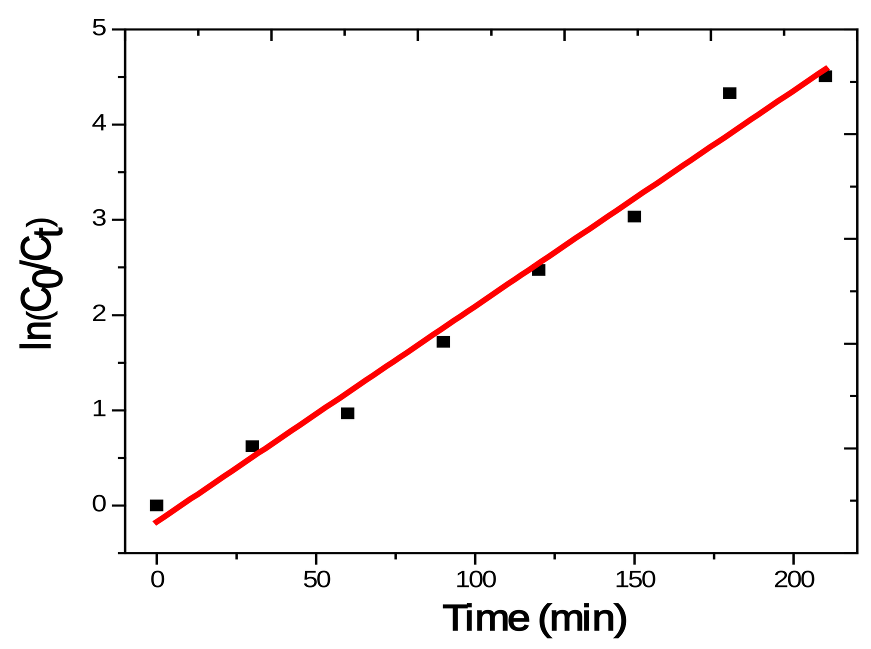
UV–Vis spectral changes of Malachite Green (λmax=618 nm) as a function of reaction time



Photocatalytic degradation of Malachite Green on α-Fe_2O_3 nanorod under solar light irradiation



The Malachite Green concentration changes under the natural sunlight irradiation over α-Fe_2O_3 nanorod



Kinetics of different irradiation time

Conclusions

- We have synthesized α-Fe_2O_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 α-Fe_2O_3 (hematite) phase was confirmed by XRD and FTIR analysis.
- The UV -VIS-DRS spectra shows that the prepared α-Fe_2O_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.

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References

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