Synthesis and comprehensive characterization of metal oxide nanoparticles for enhanced catalytic performance

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ABSTRACT

A facile chemical route was used to produce metal oxide nanoparticles with controlled shape and crystallinity. The synthesised materials were characterised by ultraviolet-visible spectroscopy (UV-Vis). Surface area analysis by scanning electron microscopy (SEM), transmission electron microscopy (TEM), and X-ray diffraction (XRD). Structural and morphological studies confirmed the successful production of nanoscale mixed metal oxides. The synthesized nanoparticles are found to have various applications, showing strong photocatalytic performance due to its high surface-to-volume ratio enhancing pollutant adsorption and catalytic efficiency under visible light radiation. This strategy illustrates how mixed oxides absorb visible light, generate charge carriers, and efficiently produce reactive radicals that break down pollutants, making them highly effective for photocatalysis in environmental remediation.

KEYWORDS : nanoparticles, hydrothermal synthesis , nickel cobalt oxide , binary composite,photocatalysis.

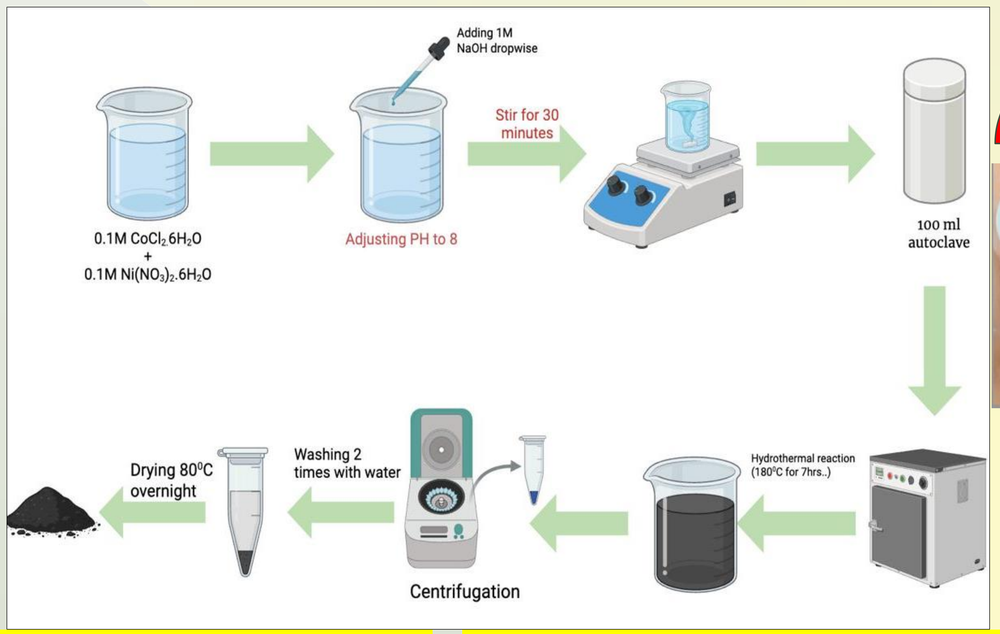
INTRODUCTION

Nanomaterials have become an important part of modern research because of their unique electrical, optical, and catalytic properties. Among them, mixed metal oxides like **cobalt–nickel oxide ($CoNi_2O_4$)** are especially useful due to their high conductivity, redox activity, *and stability. These materials are widely used in energy storage, sensors, and environmental applications.

In recent years, **green chemistry approaches** have gained importance for producing nanomaterials in an eco-friendly and sustainable way. Green synthesis methods aim to minimize toxic chemicals, reduce waste, and use safer reagents.

In this work, **$CoNi_2O_4$ nanoparticles** were synthesized using a **one-step hydrothermal method** based on green chemistry principles. **Urea** served as a mild and eco-friendly precipitating agent that slowly releases hydroxide ions, while **CTAB** acted as a biodegradable surfactant to control particle size and prevent agglomeration.

MATERIALS AND METHODOLOGY



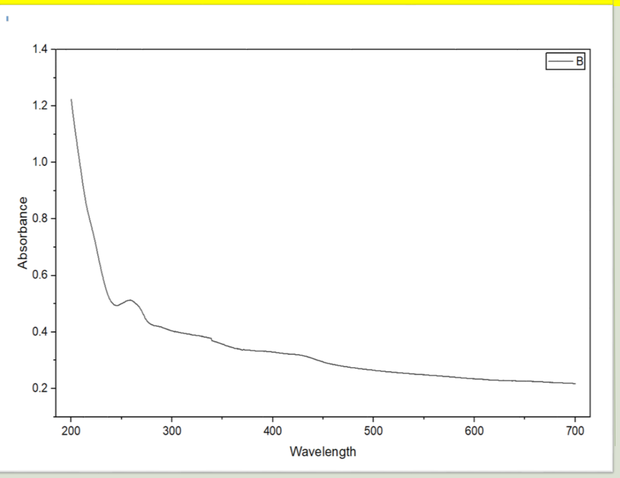
As-synthesied $NiCo_3O_4$

SYNTHESIS

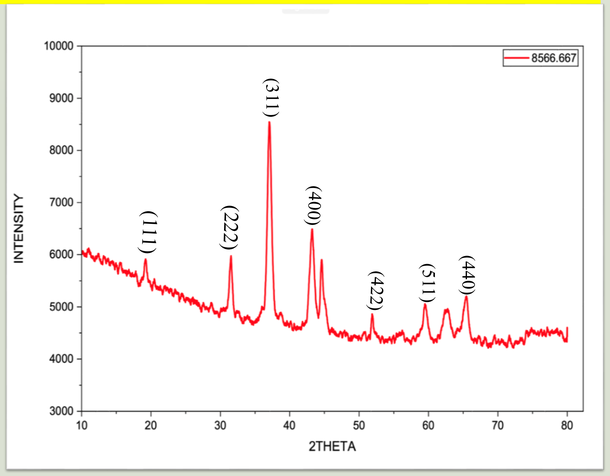
Nickel–cobalt ferrite nanoparticles were synthesized .

0.1 M solutions of **$CoCl_2 \cdot 6H_2O$** and **$Ni(NO_3)_2 \cdot 6H_2O$** (25 mL each) were prepared and mixed. **CTAB (0.91 g)** and **urea (0.32 g)** were added as morphology and precipitation control agents. The pH was adjusted to basic using **1 M NaOH**, and the mixture was stirred for **30 min**. The solution was transferred to a **100 mL autoclave** and heated at **180 °C for 7 h**. After cooling, the precipitate was centrifuged, washed twice with water, and **dried at 80 °C overnight** to obtain the final product.

CHARACTERIZATION



Uv visible graph of Nickel Cobalt Oxide Nanoparticles



XRD graph of Nickel Cobalt Oxide Nanoparticles

APPLICATIONS

1.SUPERCAPACTIORS- Nanoparticles is used as an electrode material.

2.BATTERIES- Effiicent stable cycling performance improve battery life and effeciency

3.CATALYSIS for synthetic chemistry

4.ELECTROCATALYSIS-Efficient catalysts for water splitting.

5.PHOTOCATALYSIS- Efficiently absorb light and produce species that can degrade dyes etc.

FUTURE PROSPECTS

Future studies may focus on:

- Developing **composite structures** with conductive carbon materials for improved performance.
- Exploring **scaling-up and cost-effective production** methods.
- Investigating **magnetic, catalytic, and sensing properties** for multifunctional applications.
- Integrating these nanomaterials into **next-generation sustainable energy systems** and **smart electronic devices**.

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