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Biosynthesis of Cobalt Oxide Nanoparticles Using by Costus igneus Plant

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Abstract

Nanotechnology is gaining popularity in the 21st century for its capacity to modify metals into nanoparticles. Nanotechnology research suggests that green chemistry can manufacture valuable nanomaterials. The main of the study was to produce cobalt nanoparticles to determine its antibacterial property and to check its photocatalytic activity for degradation of dyes. It has become crucial to biosynthesize efficient, secure, and affordable nanoparticles that we use for the treatment of various infections, including surgical site infection and wound infection, due to the rapid development of microbial resistance to numerous antibiotic drugs. Cobalt oxide, a multifunctional, anti-ferromagnetic p-type semiconductor with an optical bandgap of ~2.00 eV, exhibits remarkable catalytic, chemical, optical, magnetic, and electrical properties. In our study, cobalt oxide nanoparticles were prepared by the green synthesis method using leaves of Costus igneus plant which also known as insulin plant. Costus igneus belongs to Costaceae family. X-ray diffraction and SEM techniques were used to confirm the synthesis of cobalt nanoparticles (XRD).

Index Terms- Costus Igneus plant, CoO nanoparticles, biological synthesis of nanoparticles

Introduction

The creation, characterisation, manufacturing, use, and control of structures and systems by manipulating size and form at the nanoscale is known as nanotechnology.[1] Typically, materials in this range might have characteristics that differ significantly from what is

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anticipated for materials with greater dimensions. A recent example of an interdisciplinary field, nanoscience is based on the basic characteristics of things at the nanoscale. [2,3]

Figure 1: Costus igneus plant

The production of environmentally friendly nanomaterials with high specifications requires a green method. Plant extracts containing secondary metabolites, such as phenols, amides, flavones, and carboxylic acids, act as stabilizing and reducing agents in the reaction that creates nanoparticles for oxide fuels. These extracts also contain plant components that make up anti-particles. about germs and the affordability, efficiency, and environmental safety of this technology. Chemical techniques encompass the extraction-free reduction of chemicals[4], electrochemical processes[5], microemulsion, chemical precipitation, chemical vapor condensation, and pulse electrodeposition. [6]

There are billionths of a meter in a nanometer (nm). For To The proteins in the bacterial membrane that contain sulfur interact with the DNA and these proteins within the cell when cobalt oxide nanoparticles are present. The respiratory chain and cell division ultimately result in cell death, which is the preferred target of the nanoparticles. The bacterial cells are enhanced in their bactericidal action by the release of cobalt oxide by the nanoparticles. [7] Due to their widespread usage as color tones in the textile, printing, rubber, cosmetics, plastics, and leather sectors, dye-based items draw a sizable share of fast-moving consumer goods to humans [8,9,10,11,12]. There are three main types of dyes: non-ionic, cationic, and anionic. Due to their widespread usage as color tones in the textile, printing, rubber, cosmetics, plastics, and leather sectors, dye-based items draw a sizable share of fast-moving consumer goods to humans [8,9,10,11,12]. There are three main types of dyes: non-ionic, cationic, and anionic. Due to their extreme stability, these dyes can only break down at temperatures higher than 200 °C [9,10,11,12]. The health of people and aquatic life in the environment is put at risk by the presence of dangerous coloring compounds in industrial effluent [10,11,12]. Of these, cationic dyes are more vibrant, but they also have some harmful qualities for ecology, people, and the environment [11,12]. A typical cationic dye used in the paper, textile, cosmetic, leather, and food sectors is methylene blue [11,12]. Following the application of these dyes, improper dye pollutant discharges into water bodies pose a serious issue. Numerous health hazards, including gastrointestinal tract issues, respiratory issues, brain failure, and ocular irritation have all been related to it [12].

Numerous techniques, such as enzymatic procedures, photodegradation, chemical coagulation, electrochemical removal, ozonation, ion exchange, sonication, membrane filtering, and physical adsorption, have been investigated for the removal of the MB dye molecule from industrial effluent. Because of its straightforward procedure, simple catalytic recovery, and low secondary pollutant production seismology, photocatalysis is becoming more and more popular among these commercial techniques. In dye treatments, zeolites, metal oxides, conducting polymers, and other substances are employed. Many transition metals and their oxide nanoparticles have been produced and evaluated for photocatalytic efficacy due to their exceptional semiconducting characteristics and notably large surface area. Photocatalytic dye degradation is a frequent use for metal oxides, including ZnO, CuO, TiO2, AgO, and CoO. These are some applications of nanoparticles.[13]

Materials and Methods

1) **Chemicals and reagents**

In this study Distill water (DW) was used as a solvent for preparation of aqueous solution, cobalt chloride hexahydrate ($CoCl_2.6H_2O$), Costus Igneus Leaves (25 g), ethanol is used in the preparation of Costus Igneus leaf extract.

2) **Preparation of Costus Igneus Leaf Extract**

Wash the Costus Igneus Leaves with water to remove dirt from surface and wipe with cloth. Weigh 25 g of leaves. Now, cut the leaves in small pieces and crush it using mortor and pestle. During crushing, add 20-25 mL of ethanol and crush it well. Filter it using muslin cloth and store the extract in the clean and dry bottle and place the bottle in cool and dry place.

Characterization of Extract Via UV-VISIBLE Spectroscopy

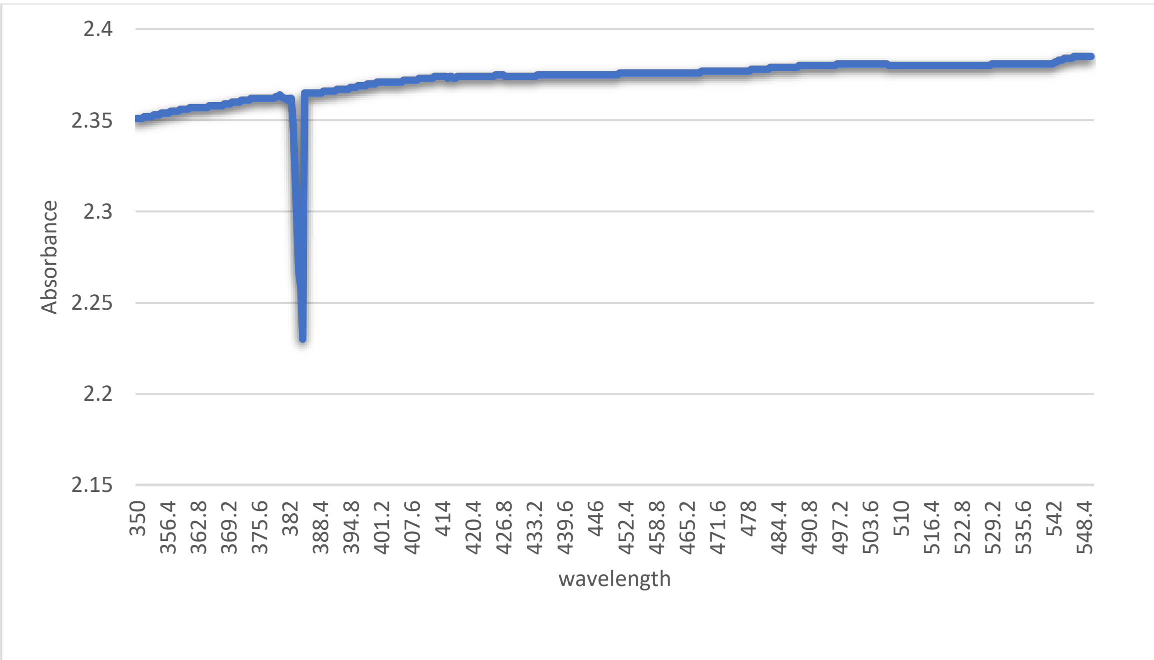

Figure 2: UV Spectroscopy of Costus Igneu

Synthesis of Cobalt Oxide Nanoparticles

A new 1 M cobalt chloride hexahydrate aqueous solution ($CoCl_2.6H_2O$), which was obtained from the Mithibai College Chemistry Laboratory. To 15 ml of 1M solution of cobalt chloride hexahydrate 15 ml of the seed extract was added. The system was maintained in a boiling water bath to synthesize cobalt nanoparticles for 30 minutes. A change in colour was noticed. Next, the mixture was filtered using a vacuum. The filtrate obtained then is dried in an oven for 10 hours. The solid is then weighed and transferred into a boat furnace. The boat furnace is kept in a thermo-furnace. The temperature of the furnace was kept at 500^0C for 6 hours. After 6 hours, the boat was removed from the furnace and the nanoparticles were obtained. The yield of the copper nanoparticles was 0.127g.

Figure 3: Cobalt Oxide Nanoparticles

Results

1) **XRD Analysis**

XRD is taken to further confirm of CoO nanoparticles. Crystal lattice indices were performed using the XRD pattern of CoO nanoparticles. XRD diffraction peaks of CoO nanoparticles were observed at 28.78°, 31.33°, 44.58°, 47.50°, 59.57° and 66.31° were assigned to (2 0 0), (2 2 0), (3 1 1), (4 0 0), and (4 2 2) crystal planes of the cubic crystal structure of the CoO nanoparticles. All diffraction peaks of sample correspond to the characteristic cubic crystal structure of CoO nanoparticles. The crystalline size of the CoO nanoparticles was also calculated with the help of strong intensity peak using Debye–Scherrer's equation. The following the cubic crystal structure was confirmed using the JCPDS data(01-075-0417) which corresponds to the CoO.[14]

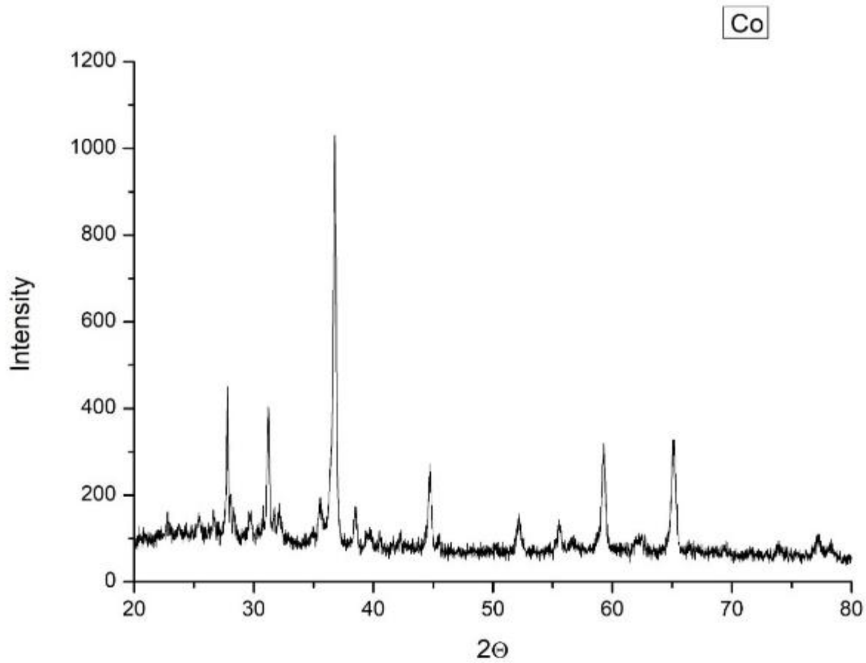

Figure 4: XRD Image of CoO Nanoparticles

2) SEM Analysis

The SEM image demonstrates CoO nanoparticles with a variety of shapes and sizes.” The particles are visible to be mostly irregular, with a few cubic shapes evident. The particle size is 5µm, with some bigger aggregates present. The particles’ surfaces appear rough, with obvious porosity and roughness. Some regions of the image exhibit particle clumping, while others appear to be distributed. Overall, the image indicates a complicated morphological structures of the CoO nanoparticles.[14]

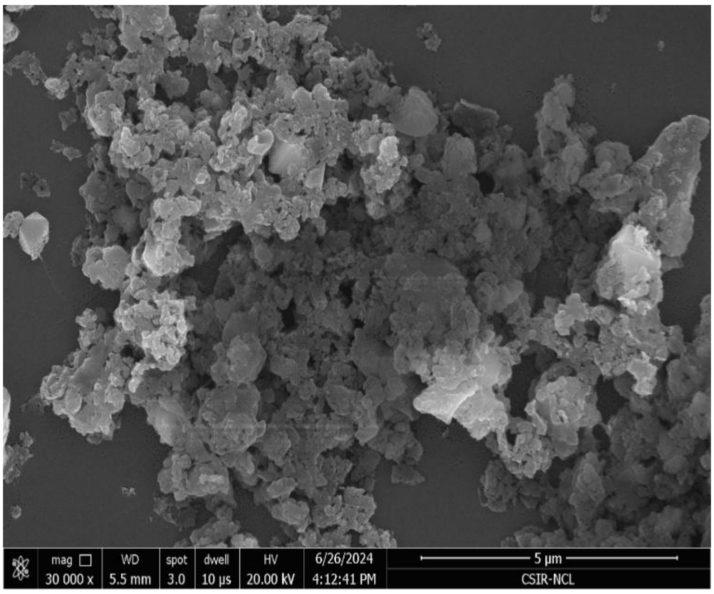

Figure 5: SEM Image of CoO Nanoparticles

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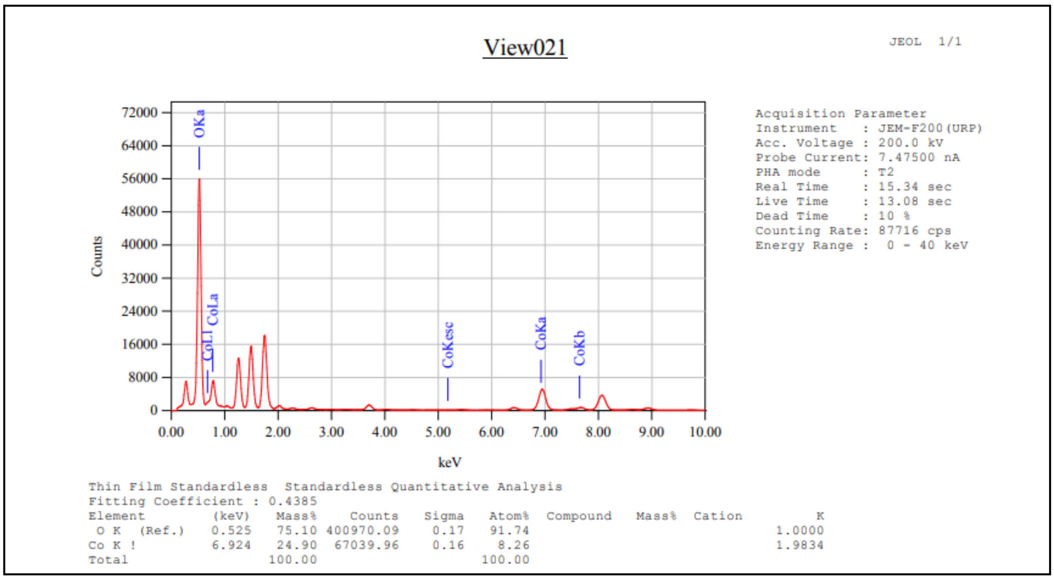
Transmission Electron Microscopy (TEM) of analysis of Cobalt Oxide Nanoparticles:



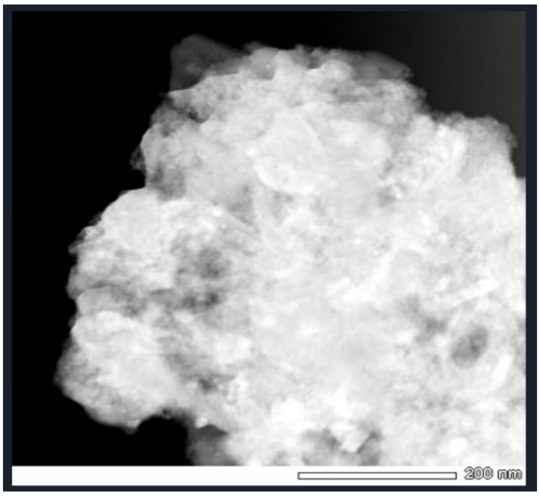
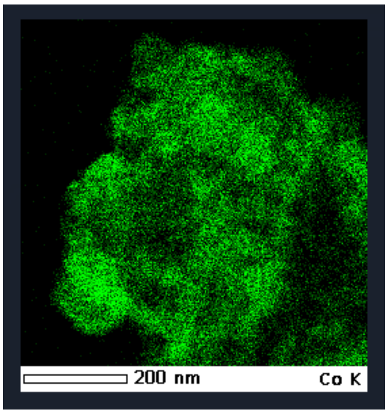
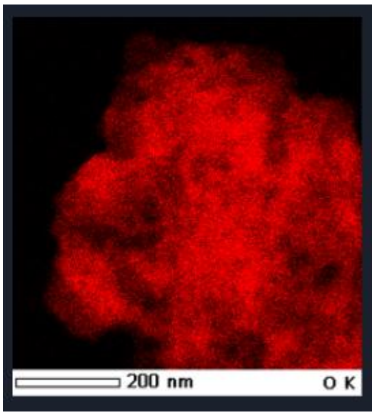


Figure 3.1





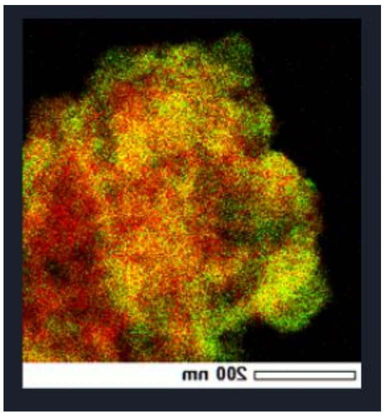


Figure 3.2 **Figure 3.3** **Figure 3.4**

Figure 3.1, 3.2, 3.3 and 3.4: Transmission Electron Microscopy (TEM) of analysis of Cobalt Oxide Nanoparticles

Interpretation of TEM:

A cluster of different-sized and shaped cobalt oxide (CoO) nanoparticles can be seen in the TEM picture. Van der Waals forces are probably the cause of the particle's coagulation. Certain particles have porous or uneven surfaces. In line with CoO, the nanoparticles show a cubic crystal shape. Different growth methods during synthesis are suggested by the mixing of spherical and cubical forms. Particles may change in optical, electrical, or magnetic characteristics as a result of clustering. Surface porosity or roughness may have an impact on applications involving catalysis or sensing. CoO nanoparticles of different sizes and shapes, crystalline structures, and aggregation are shown by the TEM analysis. Understanding these traits is essential to comprehending the material's qualities and possible uses in industries including sensing, energy storage, and catalysis.

CONCLUSION

A biological method for synthesizing cobalt oxide nanoparticles has been established utilizing *Costus Igneus* leaves extract. This process reduces cobalt chloride hexahydrate to cobalt oxide nanoparticles in a straightforward, dependable, and environmentally beneficial manner. Plants may play a role in green manufacturing of nanoparticles as new technologies are developed.

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