HYDROTHERMAL SYNTHESIS OF COBALT NANOPARTICLES BY USING PASSIFLORA LIGULARIS PEEL EXTRACT

RAMAPRIYA CHANDRAMOULI*, THENMOZHI RAMASAMY*, P.SWATHI[1], T. KANIMOZHI[2]

[*]Research Scholar ,Department of Chemistry,Mother Teresa Womens University,Kodaikanal, Dindigul,Tamil Nadu, India.

[*]Associate professor, Department of chemistry, Sakthi College of Arts And Science For Women, Oddanchatram, Dindigul, Tamil Nadu, India.

[1,2]PG&Department of Chemistry, Sakthi College of Arts And Science For Women, Oddanchatram, Dindigul, Tamil Nadu, India.

Abstract : In the present study, cobalt nanoparticles (CoNPs) were synthesized through a hydrothermal approach using *Passiflora ligularis* peel extract as a natural reducing and stabilizing agent. The synthesized nanoparticles were systematically characterized using UV–Visible spectroscopy, Fourier Transform Infrared (FTIR) spectroscopy, X-ray Diffraction (XRD), Field Emission Scanning Electron Microscopy (FESEM), and Energy-Dispersive X-ray (EDAX) analysis. The UV–Visible spectrum of *Passiflora ligularis*–mediated cobalt nanoparticles (PL-CoNPs) exhibited two prominent absorption peaks at 273.7 nm and 513 nm, confirming nanoparticle formation. FTIR analysis revealed various functional groups within the range of 500–4500 cm^{-1}, indicating the involvement of phytochemicals from the peel extract in nanoparticle synthesis and stabilization. XRD results showed a distinct diffraction peak at 22°, confirming the crystalline nature of the cobalt nanoparticles. FESEM analysis revealed mixed morphologies, including rod-shaped, spherical, and agglomerated structures. EDAX analysis further confirmed the elemental composition and the presence of cobalt as the dominant element. These results demonstrate that *Passiflora ligularis* peel extract is an effective, eco-friendly source for the synthesis of cobalt nanoparticles.

***Keywords*: Cobalt nanoparticles, *Passiflora ligularis* Peel extract, Hydrothermal synthesis, FESEM, EDAX**

1.Introduction

Nanotechnology has become a vital area of research due to its extensive applications in modern science and technology[1]. Nanoparticles are typically defined as materials with at least one dimension less than 100 nm[2]. The synthesis of nanoparticles generally follows two main strategies: top-down and bottom-up approaches[3]. In recent years, nanoparticles have attracted considerable attention in fields such as catalysis, medicine, electronics, environmental remediation, and energy applications.Nanoparticles can be synthesized using physical, chemical, solvothermal, hydrothermal, and green synthesis methods. Among these, green synthesis has gained prominence due to its environmental compatibility, cost-effectiveness, and reduced use of toxic chemicals[4]. Plant-based extracts are particularly advantageous as they contain bioactive compounds that act as natural reducing and stabilizing agents Passiflora ligularis, a member of the Passiflora genus, is widely distributed from Mexico to Bolivia, especially in the Andean regions at altitudes of 1,500–2,500 m above sea level[5]. The plant holds significant economic and medicinal value, as its fruits are consumed as food and used in traditional medicine. Variations in physical and chemical properties such as fruit weight, pulp content and pH help distinguish different genotypes[6]. Traditionally, *P. ligularis* has been used for digestive disorders, diarrhea, bruises, infections, back pain, and mumps. Scientific studies have also highlighted its role in managing cardiovascular diseases, diabetes, and neurodegenerative disorders[5].Cobalt nanoparticles are of particular interest due to their excellent catalytic, magnetic, electronic, and chemical properties. Their reduced size and enhanced surface area make them suitable for a wide range of biomedical and technological applications. Recently, eco-friendly synthesis routes for cobalt nanoparticles have gained importance, as they offer improved control over particle size, surface characteristics, and magnetic properties while minimizing environmental impact[7].

2.1 Experimental Materials

Fresh *Passiflora ligularis* fruits were collected from the local region of Kodaikanal, Tamil Nadu, India.

2.2 Preparation of *Passiflora ligularis* Peel Extract

The collected fruits were thoroughly washed with distilled water and air-dried. The peels were separated, powdered, and 10 g of the peel powder was boiled with 200 mL of distilled water for 30 minutes. The extract was allowed to cool to room temperature and subsequently filtered using Whatman No. 1 filter paper. The obtained filtrate was used for the synthesis of cobalt nanoparticles.

2.3 Synthesis of Cobalt Nanoparticles

The aqueous peel extract was stirred continuously using a magnetic stirrer for 1 hour. During stirring, 90 mL of cobalt acetate solution was mixed with 10 mL of *Passiflora ligularis* peel extract. A 0.1 N NaOH solution was then added dropwise to the mixture. The resulting solution was transferred into a Teflon-lined hydrothermal autoclave and heated in a hot air oven for 1 hour. After completion of the reaction, the autoclave was allowed to cool naturally to room temperature. The product was filtered using Whatman filter paper to obtain the synthesized cobalt nanoparticles.

3. Characterization Techniques

3.1 UV–Visible Spectroscopy

UV–Visible spectroscopy was carried out in the wavelength range of 200–800 nm. The absorption spectrum of the synthesized cobalt nanoparticles exhibited two prominent peaks at 273.7 nm and 513 nm, confirming the formation of cobalt nanoparticles [8].

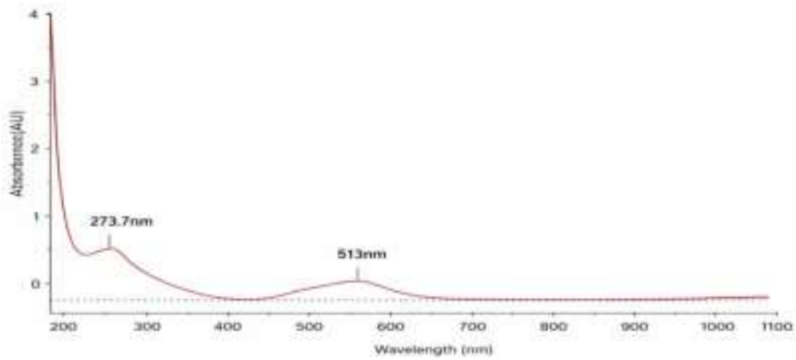

Fig3.1: UV-Visible spectroscopy

3.2 FTIR Spectroscopy

FTIR analysis of the synthesized nanoparticles revealed a broad absorption band at 3437 cm^{-1}, corresponding to O–H stretching vibrations of alcohol groups. The peak observed at 1567.56 cm^{-1} is attributed to C=C stretching of alkenes. The absorption band at 1413.50 cm^{-1} corresponds to S=O stretching, indicating the presence of sulfate groups. The peak at 1067.72 cm^{-1} is associated with C–O stretching vibrations of primary alcohols, while the band at 656.36 cm^{-1} corresponds to C–Cl stretching, indicating halogen compounds [9].

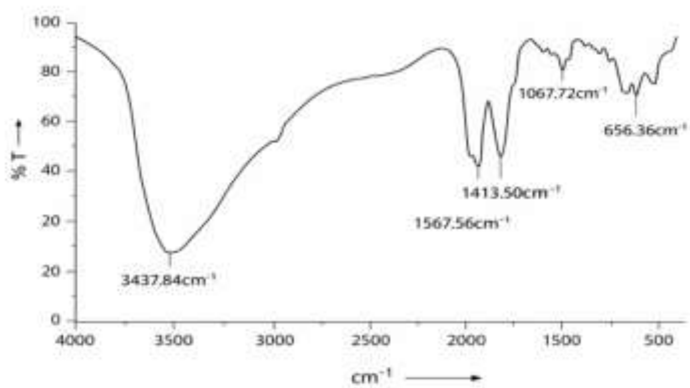

Fig3.2: FTIR spectroscopy

3.3 XRD Spectroscopy

X-ray diffraction (XRD) analysis was employed to determine the crystalline nature of the synthesized cobalt nanoparticles. The powdered sample showed distinct diffraction peaks, confirming the formation of crystalline cobalt nanoparticles. The crystallite size was calculated from the broadening of the diffraction peaks using standard methods [10].

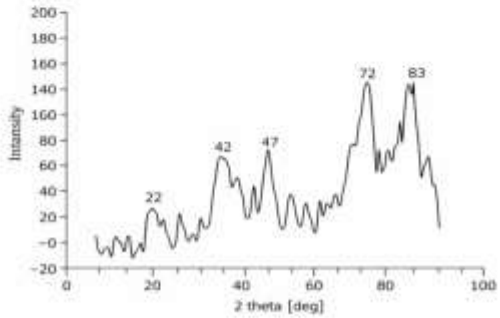

Fig3.3: XRD spectroscopy

3.4 FESEM Analysis

Field emission scanning electron microscopy (FESEM) was used to examine the surface morphology and size distribution of the synthesized cobalt nanoparticles. The images revealed relatively uniform particle distribution with
varied morphologies. Rod-shaped structures were observed in images (a) and (b), spherical nanoparticles in image (c), and agglomerated particles in image (d) [11].

Fig3.4: FESEM spectroscopy

3.5 Energy-Dispersive X-ray Analysis

Energy-dispersive X-ray (EDAX) analysis confirmed the elemental composition of the synthesized nanoparticles. The spectrum indicated cobalt as the major constituent, along with the presence of carbon and oxygen, confirming the formation of cobalt-based nanoparticles [12].

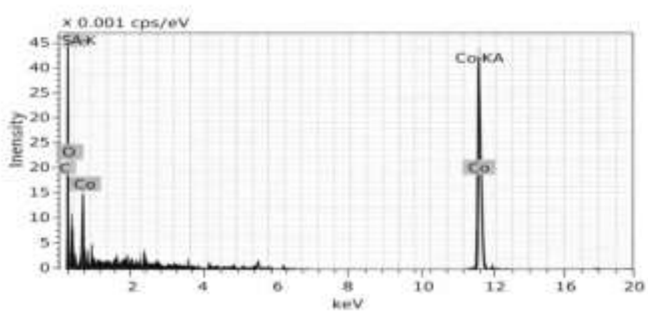

Fig3.5: Energy-Dispersive X-ray Analysis

4.Conclusion

In this study, cobalt nanoparticles were successfully synthesized using *Passiflora ligularis* peel extract through an eco-friendly hydrothermal method. The formation and characteristics of the nanoparticles were confirmed using UV–Visible spectroscopy, FTIR, XRD, FESEM, and EDAX analyses. The synthesized cobalt nanoparticles exhibited characteristic absorption peaks at 273.7 nm and 513 nm, crystalline nature, and varied morphologies including rod-shaped, spherical, and agglomerated forms. FTIR results demonstrated the involvement of phytochemicals from the peel extract in nanoparticle stabilization. EDAX analysis confirmed cobalt as the major elemental component. The results highlight the potential of *Passiflora ligularis* peel extract as a sustainable and green source for cobalt nanoparticle synthesis, with promising applications in future technological and biomedical fields.

5.Reference

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