Bioflavonoid Mediated Synthesis of Nickel Oxide Nanoparticles: Evaluation of Antioxidant and Antimicrobial Properties

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**Abstract:** The present study examines the structure and properties of nickel oxide nanoparticles synthesized via the usage of bioflavonoids. The notable antibacterial and antioxidant characteristics of the nanoparticles point to their potential use in biomedicine. Future research ought to look into their biocompatibility and effectiveness in therapeutic settings. The study aims to evaluate the characterisation, antioxidant and antimicrobial properties of the synthesized NiO nanoparticles mediated by bioflavonoids. The nickel oxide nanoparticles were synthesized by the mediation of the bioflavonoid quercetin. Their antimicrobial activity was assessed by agar well diffusion method and antioxidant activity by DPPH assay. The characterization of the nickel oxide nanoparticles confirmed the crystalline nature of the nanoparticles. The nickel oxide nanoparticles exhibited excellent antimicrobial and antioxidant properties. Bioflavonoid mediated synthesis of nickel oxide nanoparticles provides an ecofriendly approach. Their excellent antimicrobial and antioxidant properties render hope for its future use in biomedical applications.

**Keywords:** Nickel oxide, nanoparticles, bioflavonoid, quercetin, antimicrobial, antioxidant

# INTRODUCTION

Among the most exciting emerging fields of the twenty-first century is nanotechnology.Solid particles or particulate dispersions with sizes between 10 and 1000 nm are referred to as nanoparticles [(Mohanraj & Chen, 2006)](https://paperpile.com/c/IkHjwO/7IoQm). In the study of nanotechnology, networks with geometrical features ranging from solitary atomic particles to micron-sized proportions are created and used, and the resulting nanostructures are then assimilated into more complex structures.Innovative opportunities for the development of creative nanostructured supplies and nanosystems in order are presented by the identification of fresh substances, occurrences, and procedures at the nanometer as well as the advancement of unique investigative and theoretical approaches[(Merchant et al., 2025; Shenoy et al., 2025)](https://paperpile.com/c/IkHjwO/umxj+iOjd). Regarding its applications in energy, electronic devices, healthcare, farming, and other fields, nanoscale research and nanotechnologies are projected to make numerous advances in the near future. The pace of these advancements is quickening [(Aparna et al., 2021; Poornima et al., 2021; Verma & Muthuswamy Pandian, 2021)](https://paperpile.com/c/IkHjwO/qFqLE+m0ln3+pjGxN)[(“An Introduction to Nanotechnology,” 2019)](https://paperpile.com/c/IkHjwO/XI9cR).Particulate fragments or solid particles having a variety of sizes of 10–1000 nm can be referred to as nanoparticles [(Mohanraj & Chen, 2006)](https://paperpile.com/c/IkHjwO/7IoQm). A wide range of biomedical functions can be implemented with nanoparticles, making them an extremely appealing foundation. Biological molecules communications, biological detection colorimetric, fluorescence, electrochemical, pharmaceutical delivery systems, as well as biological molecules carriers are all applications for nanoparticles [(De et al., 2008)](https://paperpile.com/c/IkHjwO/ZV7Ie). These substances can have varying overall dioptre shapes (0D, 1D, 2D, 3D). The size of the substance might affect its physicochemical characteristics, mainly its optical qualities. The typical hues of 20-nm gold (Au), platinum (Pt), silver (Ag), and palladium (Pd) nanoparticles are wine red, ranging yellowish gray, black, and pitch black, in that order [(Merchant et al., 2022; Pandiyan et al., 2022)](https://paperpile.com/c/IkHjwO/TbtOY+04pLk)[(“Nanoparticles: Properties, Applications and Toxicities,” 2019)](https://paperpile.com/c/IkHjwO/tMogr). In addition to larger-scale usage like ceramics, small, chemically inactive particles have been widely used in colorants, polymeric fillers, and finishes for surfaces [(Shenoy et al., 2023; Singh et al., 2024)](https://paperpile.com/c/IkHjwO/t5UJ+SHPD). In addition to modifying their mechanical, electrical, surface, or visual characteristics, polymeric fillings are widely employed in the alteration of polymer films' permeation [(Ganapathy & Professor and Head of Department of Prosthodontics,, 2021; Merchant et al., 2022; Pandiyan et al., 2022)](https://paperpile.com/c/IkHjwO/TbtOY+04pLk+IDCsH). Zinc oxide and nanoparticulate titania may now be produced at a reasonable cost thanks to more recent developments in aerosol synthesis [(Wadhwani et al., 2022)](https://paperpile.com/c/IkHjwO/MZVcj). Titania's high refractive index allows for excellent color depth and powerful optical effects in pigments [(Chokkattu et al., 2022; Ramamurthy et al., 2022)](https://paperpile.com/c/IkHjwO/IYO4k+xc2pc). Amorphous silica (E551) is a substance that is added to powders to improve their rheology (better flow), acts as an anti-caking agent in food goods, can be added to animal feed, and supports heterogeneous catalysts. A well-known illustration of an effective application is window panes with enhanced anti-scratch or self-cleaning qualities for customers [(Stark et al., 2015)](https://paperpile.com/c/IkHjwO/sp1Ro).

Since nickel oxide nanoparticles exhibit unique physical, chemical, visual, and biological features, they possess importance in multiple fields. Nickel oxide nanoparticles have been synthesized using a variety of chemical processes due to their wide range of applications in several industries [(Jain & Verma, 2022; Marya et al., 2022)](https://paperpile.com/c/IkHjwO/wvnUa+HznFv) [(Berhe & Gebreslassie, 2023)](https://paperpile.com/c/IkHjwO/W4Kfq). Usage for nickel nanoparticles are possible in a number of domains, such as energy generation, magnetic fields, electronics, and biology. They are used to catalyze a variety of organic reactions, generation of stilbenes from alcohol through Wittig-type olefination, α-alkylation of methyl ketone, hydrogenating of olefins, reduction of aldehydes and ketones, and chemoselective oxidative coupling of thiols. Their outstanding reactivity, ease of use, and environmental friendliness make them highly reactive. Additionally, they accelerate some inorganic reactions, such as the ammonia breakdown process. Their use in the production of carbon nanotubes (CNTs) is one of their more recent uses [(Sreevarun et al., 2023)](https://paperpile.com/c/IkHjwO/pt1QO) [(Imran & Rani, 2016)](https://paperpile.com/c/IkHjwO/4YhIH). Nickel oxide nanoparticles are widely used in battery electrodes, photo-electron equipment, ion preservation materials, gas sensors, fuel cell catalysts, dye-sensitized photocathodes, electrochromic films, cancer prevention, cytotoxic properties, and non-enzymatic glucose sensors, among other applications. Antibacterial effectiveness of nickel oxide nanoparticles is demonstrated against both gram-positive and gram-negative pathogens [(Adel et al., 2023)](https://paperpile.com/c/IkHjwO/lduOA) [(“Structural and Optical Properties of Nickel Oxide Nanoparticles: Investigation of Antimicrobial Applications,” 2020)](https://paperpile.com/c/IkHjwO/v9v0k).

Nanoparticle synthesis is primarily carried out with a bottom up and top down processes. Bottom up method revolves around the idea of conversion of tiny atoms to nanoparticles [(Subramanian & Harikrishnan, 2023)](https://paperpile.com/c/IkHjwO/nAOP5). Some of the procedures include sol-gel,pyrolysis,spinning,chemical vapour deposition and biological synthesis.Top down method revolves around the idea of synthesizing nanoparticles from a bigger substance to tiny nanoparticles with excellent application [(Solanki et al., 2023)](https://paperpile.com/c/IkHjwO/yx9IS).Techniques like nanolithography, laser ablation, mechanical milling, thermal decomposition as well as sputtering are employed in top down method [(Ganapathy & Professor and Head of Department of Prosthodontics2021)](https://paperpile.com/c/IkHjwO/oazV0)[(Anu Mary Ealia & Saravanakumar, 2017)](https://paperpile.com/c/IkHjwO/612pd). Chemical techniques that are employed for the synthesis of nanoparticles are dangerous to the environment as the toxins are taken up by the surface.This reason paved the way for biological synthesis of nanoparticles as it is eco friendly.Biological synthesis involves the employment of fungi,bacteria,enzymes for the synthesis of nanoparticles which can be metals and metal oxides [(Chokkattu et al., 2023)](https://paperpile.com/c/IkHjwO/n4uG8).There are two types for synthesis of nanoparticles using fungi which are intracellular and extracellular.When enzymes are present, the movement of ions into microbial cells to create nanoparticles,this procedure is employed for intracellular synthesis whereas Fungal extracellular production of nanoparticles is primarily understood due to the large secretory elements of the fungi that participate in the reduction and capping of nanoparticles [(Laghari et al., 2023; Ramakrishnan et al., 2023)](https://paperpile.com/c/IkHjwO/kRc7u+sGjxv).[(*Website*, n.d.-a)](https://paperpile.com/c/IkHjwO/KoeUw).

Bioflavonoids are secondary compounds derived from plants and known for their excellent antioxidant properties.The bioflavonoid compound rutin was used to complete the biogenesis of TiO2NPs, and the formation of an orange-colored deposition that transitioned from light orange to dark orange served as confirmation [(Muthuswamy Pandian et al., 2022)](https://paperpile.com/c/IkHjwO/h4GCh). The orange-colored TiO2NPs powder changed to a white-colored powder at the conclusion of the calcination procedure [(“Bioflavonoid Mediated Synthesis of TiO2 Nanoparticles: Characterization and Their Biomedical Applications,” 2022)](https://paperpile.com/c/IkHjwO/j3xRQ). Natural bioflavonoid rutin was employed in the study to produce ecologically friendly ZnO nanoparticles. The findings demonstrated that rutin effectively facilitated the green chemistry-based synthesis of ZnO nanoparticles. The visual, structural, and pharmacological characteristics of ZnO-R nanoparticles have been investigated in this work [(Muthuswamy Pandian et al., 2022; Ramakrishnan et al., 2023)](https://paperpile.com/c/IkHjwO/h4GCh+kRc7u) [(Saleemi et al., 2022)](https://paperpile.com/c/IkHjwO/iKrGb).

Pedalium murex leaves are high in compounds such as flavonoids, saponins, triterpenoids, steroids, phenol compounds, lipids, fatty acids, carbohydrates, and amino acids. Numerous research have documented the benefits of Pedalium murex plants, including their antibacterial, anti-inflammatory, anti-inflammatory, anti-nephrolithiasis, anti-hyperlipidemic, and anti-ulcer properties. The investigation created an innovative method using Pedalium murex leaf extract, having potent biological properties and potential use in medicine, for the environmentally friendly manufacturing of nickel oxide nanoparticles [(“Biofabrication of Nickel Oxide Nanoparticles from Pedalium Murex Leaf Extract: A Promising Approach for Biomedical and Environmental Applications,” 2023)](https://paperpile.com/c/IkHjwO/cawgM).

At the identical concentration, the activity of antioxidants was less than that of normal ascorbic acid. On the other hand, with NiO Nanoparticles, the proportions of the percentage of inhibition noted suggested a possibility for antioxidant activity [(“Biofabrication of Nickel Oxide Nanoparticles from Pedalium Murex Leaf Extract: A Promising Approach for Biomedical and Environmental Applications,” 2023)](https://paperpile.com/c/IkHjwO/cawgM). The observation that antioxidant capacity rose as the concentration of both samples increased suggests that more antioxidants are needed to counteract [(Rehman et al., 2021)](https://paperpile.com/c/IkHjwO/kxdvS). Strong evidence has been obtained for the antioxidant characteristics of NiO nanoparticles. Accordingly, NiO nanoparticles exhibit a modest TAC (total antioxidant capacity) and TRP (total reducing power) along with excellent scavenging capability.[(Ahmad et al., 2023; Rehman et al., 2021)](https://paperpile.com/c/IkHjwO/kxdvS+kRwNF)MNPs generally exhibit exceptional antioxidant capabilities, and NiO NPs' antioxidant qualities are widely known. Ni element creates a potent combination with phenolic and flavonoid compounds when NiO NPs are produced from medicinal plants, giving them special antioxidant characteristics [(Sagadevan et al., 2023)](https://paperpile.com/c/IkHjwO/cjkhG).

A sufficient quantity of liberated Ni2+ ions enters the cell wall, disrupting electron movement and affecting DNA, proteins, and mitochondria, eventually resulting in the pathogen's cell death.8\_NiONPs@GL have effective activity and stability, making them a valuable antibacterial agent for a variety of biological and environmental applications [(“In- Vitro Biosynthesis of Concentration-Induced Nickel Oxide Nanoparticles for Antibacterial Applications,” 2023; Shanan & Shanshool, 2023)](https://paperpile.com/c/IkHjwO/SyLF7+601tB). Both the amoxicillin samples and the MnCu co-doped NiO NPs display antibacterial activity against bacterial and fungal pathogens.

ROS generation is induced by the antibacterial mechanism of MnCu co-doped NiO NPs. Oxidative stress, brought on by ROS, can damage DNA, lipids, proteins, and microbial cell membranes. Additionally, because NPS mounts the bacterial cell membrane and produces ROS, releasing the cytoplasmic contents [(Alzahrani et al., 2024)](https://paperpile.com/c/IkHjwO/a4nm4).

The primary aim of the research was to synthesize nickel oxide nanoparticles by mediating the process with bioflavonoids and analyze the structure and characterisation of nanoparticles.The research also focuses on evaluating the antioxidant and antimicrobial properties.Research on this area will make nickel oxide nanoparticles biocompatible and making it suitable for biomedical applications providing a hope for the future.

# MATERIALS AND METHODS

## Bioflavonoid mediated synthesis of nickel oxide nanoparticles

20 ml each of isopropyl alcohol (CH3)2CHOH and polyethylene glycol (H(OCH2CH2)nOH) were used to dissolve 1 g of nickel (II) nitrate hexahydrate [Ni(NO3)2.6H2O].To ensure chemical dissolution, the solutions were agitated for a whole day using a magnetic stirrer.Solutions were treated with ammonium hydroxide (NH4OH) until they reached pH 11.Up until gel formed, the solutions were progressively heated to 80 degrees Celsius.NiO nanoparticles were produced by grinding the gel (M/P) after it had been dried at 200 degrees Celsius.A bioflavonoid called quercetin was added, mixed, and allowed to dry.

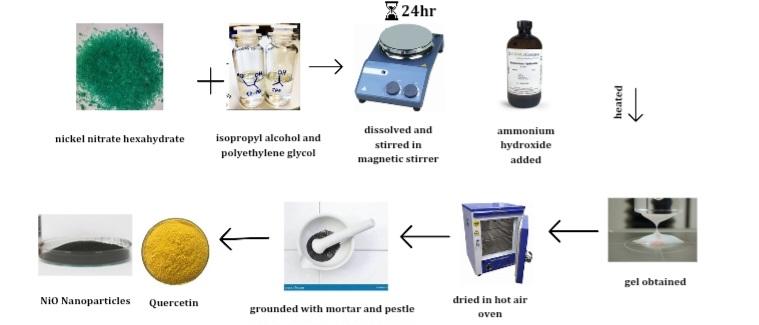


Fig1: Schematic representation of the synthesis of Nickel Oxide Nanoparticles

## Assessment of Antioxidant activity of bioflavonoid mediated synthesized nickel oxide nanoparticles

The DPPH assay was used to evaluate the nanoparticles' antioxidant properties.Using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay, the sample's capacity to scavenge radicals was determined.Following a 30-minute incubation period at 37 degrees Celsius in the absence of light, the DPPH solution's absorbance was calculated, and an optical density measurement was made at 517 nm.The percentage of scavenging activity inhibition was computed using the procedure, with vitamin C serving as a positive control.

DPPH scavenging effect(%)=A0-A1

x 100

A0

where,A0 denotes the Absorbance of control; A1denotes the absorbance of sample

## Determination of the antimicrobial activity of bioflavonoid mediated synthesized nickel oxide nanoparticles

The antibacterial activity was verified using the Agar well diffusion method. A nutrient broth was made and infused with bacterium strains, including Enterococcus and Escherichia coli.For two to three hours, it was incubated at 37 degrees Celsius.Following incubation, 0.5 McFarland Standard Mueller hinton agar was used to correct the turbidity(Chehelgerdi et al., 2023). The agar was produced aseptically and then transferred into sterile petri plates. Subsequently, the various strains of bacteria were switched within the plate. Dimethyl sulfoxide (DMSO) was added to the well for the negative control, and an antibiotic disc was placed in the media for the positive control.The plates were then incubated for 24 hours at 37 degrees Celsius, and the diameter of the incubation zone was measured.

# RESULTS

## XRD Analysis of NiO nanoparticles

In figure 1, The X axis indicates the ​​angle between the incident X-ray beam and diffracted X-ray beam and the Y axis indicates the intensity of the X rays that are diffracted. We can infer that the crystalline NiO phase is confirmed by diffraction peaks at 2 theta values of 37.3°, 43.2°, 62.5°, 75.4° and 79.3°, corresponding to the characteristic diffraction of (111),(200),(220),(311) and (222) crystal planes of the NiO nanoparticles.The peaks obtained in the XRD confirms that the NiO nanoparticles are crystalline in nature as the peaks are sharp and no noisy peaks are found.The crystallographic planes indicates the NiO nanoparticles exhibit Face Centered Cubic crystalline structure.

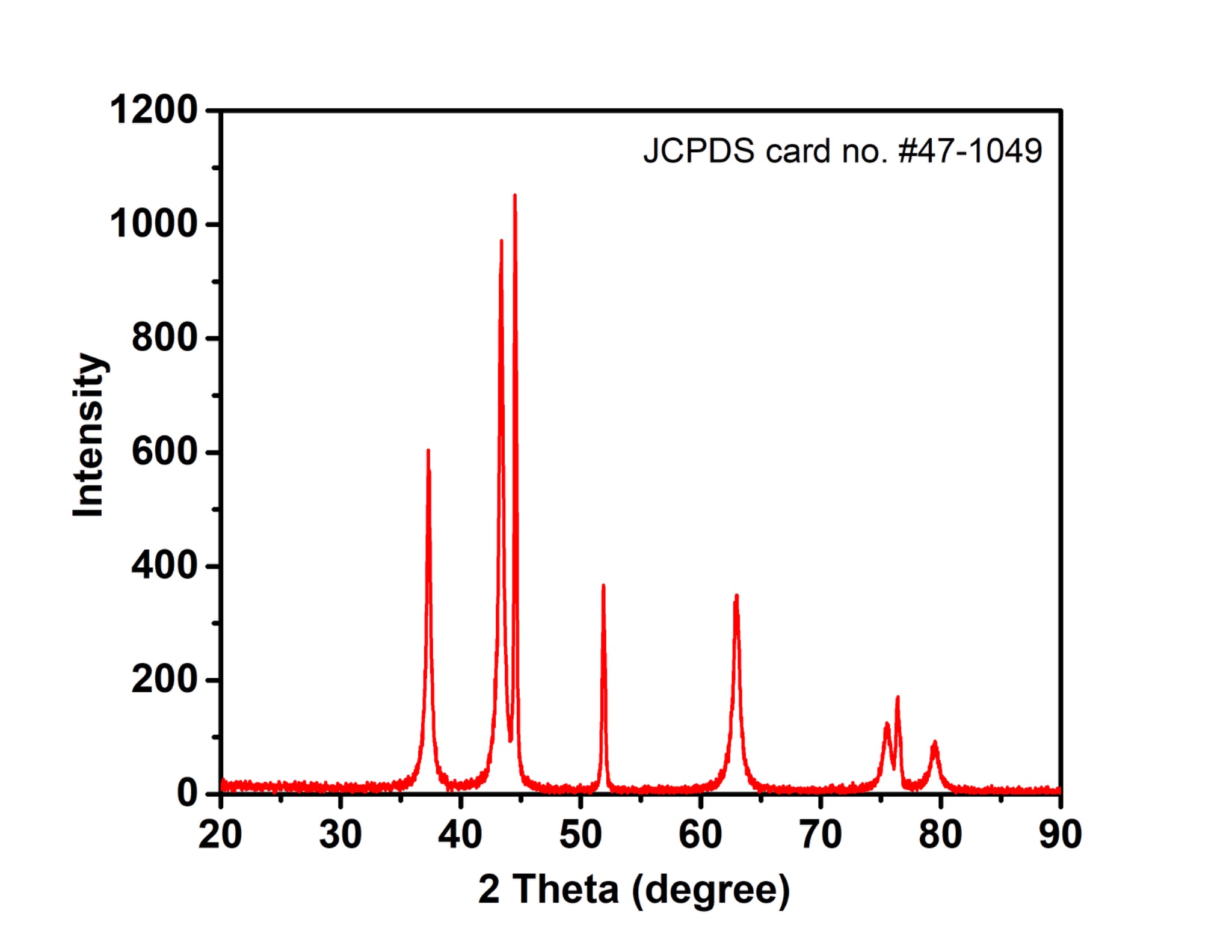
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Figure 1: X Ray Diffraction Analysis(XRD) of bioflavonoid mediated synthesized NiO nanoparticles

## FTIR Analysis of NiO nanoparticles

In the figure 2 ,The X axis indicates the number of wave cycles per unit distance denoted by 1/cm and the Y axis indicate the percentage transmission in %.We can infer that the stretching vibrations resulting from the nickel oxygen bound were found to peak at 421 1/cm and 670 1/cm.The expansiveness of a peak indicates the crystalline nature of the NiO catalyst. The bending and stretching vibrational movements of the -OH group, which were absorbed on the catalyst’s exterior from the atmosphere, resulted in the broad peak at 2979,1382,1611 1/cm. The equal and unequal extending mode of vibrations of the molecules of carbon dioxide absorbed from the air produced the absorption band at 2353 1/cm.The peak at 1167 1/cm was due to the stretching movements of carbonate molecules' C–O bonds that are adsorbed on the nanoparticles' exterior.

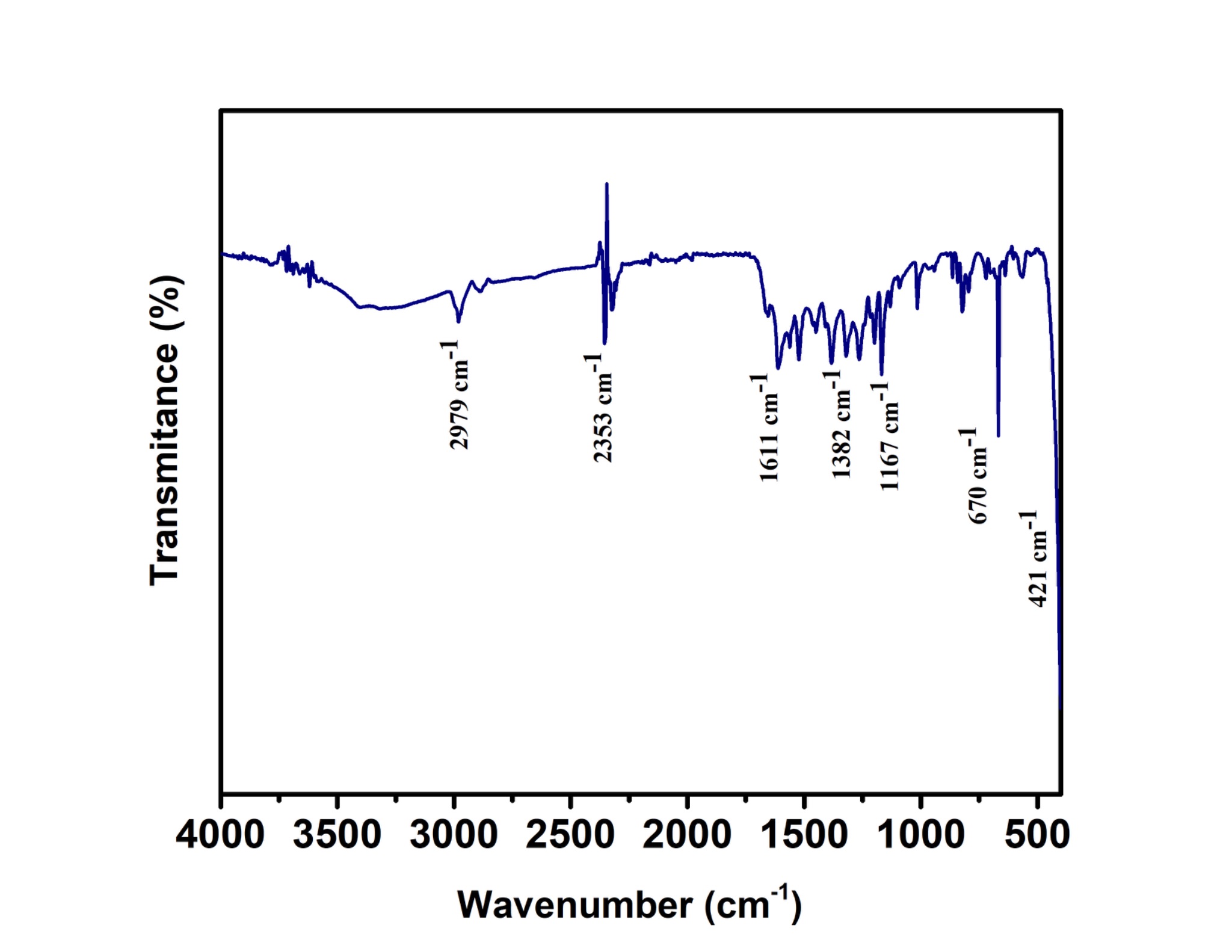
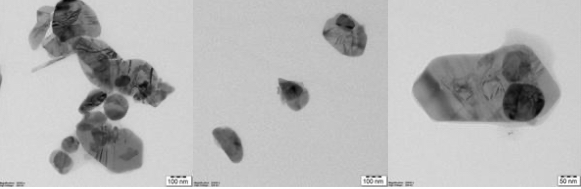
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Figure 2: Fourier Transform Infrared Spectroscopy (FTIR) analysis of the bioflavonoid mediated synthesized Nickel oxide nanoparticles.

## HRTEM of NiO nanoparticles

The sample of bioflavonoid mediated synthesized NiO nanoparticles were observed under High Resolution Transmission Electron Microscope (HRTEM). We can observe that the nanoparticles were spherical and irregular when viewed at different nanometer scales.

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1. **(b) (c)**

Figure 3: (a) (b) (c) HRTEM of the bioflavonoid mediated synthesized nickel oxide nanoparticles

## Antioxidant activity of NiO nanoparticles

The antioxidant activity of nickel oxide nanoparticles were assessed using DPPH assay. The table 1.1 shows the antioxidant activity of the nanoparticles when added at different concentrations.At the concentration of 50μg, the antioxidant activity was 33.23657 % ;at the concentration of 100μg, the antioxidant activity was 49.20174%; at the concentration of 150 μg, the antioxidant activity was 69.52104%; and at the concentration of 200 μg, the antioxidant activity was 84.03483. It can be inferred that as the concentration of the bioflavonoid mediated synthesis of nickel oxide nanoparticles increases,the antioxidant activity also increases.From the obtained results,we can conclude that the nanoparticles possess strong antioxidant activity.

The figure 3 shows the antioxidant activity of the bioflavonoid mediated synthesized nickel oxide nanoparticles.The X axis indicates the concentration and the y axis indicates the antioxidant activity. It can be inferred that as the concentration of the nanoparticles increases, the free radical scavenging activity also increases. It can be concluded that the antioxidant activity is directly proportional to the concentration of the nanoparticles.

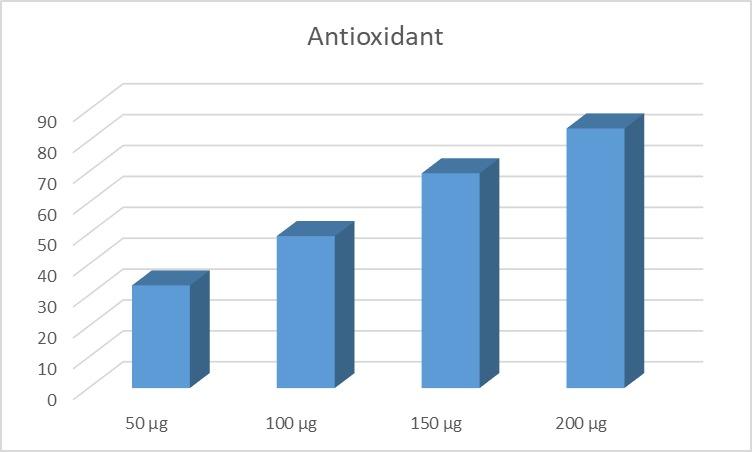
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Figure 4: Antioxidant activity of the nanoparticles in different concentrations (50μg,100μg,150μg,200μg).

## Antimicrobial activity of NiO nanoparticles

Figure 4 depicts the agar well diffusion method employed for assessing the antimicrobial activity of the nanoparticles.The wells were made using polystyrene tips and the nanoparticles were added at various concentrations(50μl,75μl,100μl).The zone of inhibition in mm was measured by a metre scale.For the bacteria E.coli,the positive control was taken to be ciprofloxacin and the negative control was added with DMSO.For the bacteria Enterococcus,the positive control was taken to ampicillin and the negative control was added with DMSO.

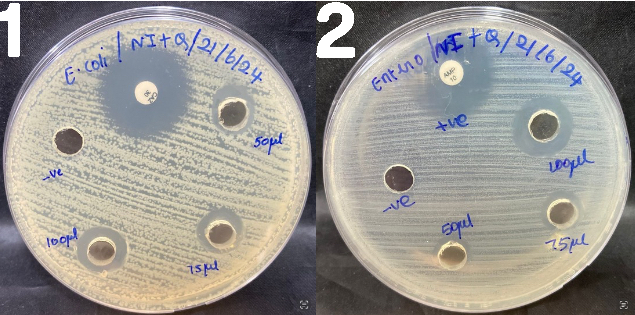


Figure 5: Antimicrobial activity of the nanoparticles in different concentrations(50μl,75μl,100μl).

The table 1.2 shows the antimicrobial activity of the nanoparticles at different concentrations against E.coli and Enterococcus. For the bacteria E.coli,at the concentration of 50 μg,the zone of inhibition was found to be 11mm.At the concentration of 75 μg,the zone of inhibition was found to be 15mm.At the concentration of 100 μg,the zone of inhibition was found to be 16mm. The zone of inhibition where the positive control Ampicillin was added, was found to be 26mm. The zone of inhibition where the negative control DMSO was added, was found to be 10mm.For the bacteria Enterococcus,at the concentration of 50 μg,the zone of inhibition was found found to be 11mm. At the concentration of 75 μg,the zone of inhibition was found to be 12mm.At the concentration of 100 μg,the zone of inhibition was found to be 17mm.The zone of inhibition where the positive control ciprofloxacin was added, was found to be 23mm.The zone of inhibition where the negative control DMSO was added,was found to be 10mm.At the concentration of 100 μg,better antimicrobial activity in Enterococcus was found which was measured as 17mm.

# DISCUSSION

XRD analysis was used to ascertain the crystallization state and composition of the as-prepared NiO spheres; the typical XRD patterns of the as-prepared NiO microspheres. Accordingly, it is evident that three NiO spheres with various morphologies displayed patterns that were comparable to each other and the standard NiO card (JCPDS NO. 47-1049). The absence of any additional distinct impurity peaks indicates that the NiO nanospheres are highly pure and crystalline. [(*Website*, n.d.-b)](https://paperpile.com/c/IkHjwO/iEShH) The sharper reflection peaks in the patterns obtained from XRD of the calcined NiO sample indicate an increase in crystallite sizes. The bulk NiO crystal planes (111), (200), (220), (311), and (222) are responsible for the elevations at 2θ=37.10°, 43.30°, 62.87°, 76.50°, and 79.22°. Based on standard data (JCPDS card no. 47–1049), these reflections are consistent with the face-centered cubic (fcc) NiO phase, which has an average lattice constant (a) of 4.175 Å and is part of the space group Fm3hm [225]. [(“Nickel Oxide Nanoparticles: Synthesis and Spectral Studies of Interactions with Glucose,” 2013)](https://paperpile.com/c/IkHjwO/3kBuR)

After heating the produced combination to 100 °C until all the water dissipated the sample was then dried for two hours at 500 °C in an ambient atmosphere. Vibratory peaks were detected at 3640, 3005, 2934, 1566, 1407, 1000, 908, 645, and 458 cm−1 for the Ni(OH)2 nanoparticles as produced. The signal at 3640 cm−1 indicated H-bonded phenols, while 3005 and 2934 cm−1 suggested carboxylic groups with OH bonds. The unique N-H stretching vibrations of the amide bond of protein molecules were represented by the doublet peaks at 1566 and 1407 cm−1.Furthermore, the structural vibrations of Ni-OH and Ni-O-Ni were indicated by the peaks between 1000 and 400 cm−1. Furthermore, peaks were seen at 2953, 1574, 1426, 964, 873, 684, and 406 cm−1 in the case of NiO (annealed at 500 °C) nanostructures. The potential cause of the modest change in the characteristic vibration at 1574 cm−1 could be attributed to the attachment with NiO, and the increase in intensity of 1426 cm−1 might be attributed to the protein amide group's connection with the NiO surface. The Bunsenite NiO phase had two different modes, with maxima located at 964 and 684 cm−1 [(Srihasam et al., 2020)](https://paperpile.com/c/IkHjwO/iqklA). At 3634 cm−1, Ni(OH)2 exhibits a narrow and robust band that is associated with the v(OH) stretching vibration. A broad, strong band at 3450 cm−1 is caused by the O–H stretching vibration of water molecules and the H–bound OH group. A peak at 1644 cm–is caused by the bending vibration of water molecules. Peaks at 1390 cm−1, 1300 cm−1, and 1030 cm−1 are attributable to the O-C=O symmetric and asymmetric stretching vibrations, as well as the C-O stretching vibrations from ambient CO2 or ethanol adsorption.The NiO nanoparticles' FT-IR spectra display a broad absorption band at 3450 cm−1, which is caused by O–H stretching vibrations, and a strong band at 425 cm−1, which is attributed to Ni–O bond vibrations.[(“Nickel Oxide Nanoparticles: Synthesis and Spectral Studies of Interactions with Glucose,” 2013)](https://paperpile.com/c/IkHjwO/3kBuR)

NiO NPs heat-treated at 300 °C produced ultrafine spherical particles, with diameters ranging from 5 to 15 nm. As the heat-treatment temperature rose to 400 °C, NiO NPs expanded to a size of around 20–40 nm and showed signs of mild particle agglomeration. As the temperature of the heat treatment rose, the agglomerations between the particles became more noticeable (Saadh et al., 2024). When NiO NPs were heat-treated to 500 °C,particles ranging in size from 30 to 70 nm were seen. Furthermore, particles ranging in size from 40 to 120 nm were seen when the heat-treatment temperature reached 600 °C [(Hong et al., 2021)](https://paperpile.com/c/IkHjwO/dyV94). Using the usual serial dilution approach, antimicrobial activity MIC, MBC, and MFC readings were determined against a selection of microorganisms at different doses of 0.08, 0.16, 0.32, 0.64, 1.28, and 2.56 µg/mL.48 Table 1 provides a summary of the findings. With no discernible turbidity, the MIC values for the extract, NiO-pure, and NiO-olive were determined to be 0.64 µg/mL, 2.65 µg/mL, and 0.32 µg/mL, correspondingly [(Alghamdi et al., 2024)](https://paperpile.com/c/IkHjwO/u4Ox0).

The antioxidant capacity rose (28%, 49%, 69%, 71%, and 84%, respectively) as the concentration of nickel oxide nanoparticles increased (20, 40, 60, 80, and 100 μg/ml). At the maximum dosage of 100 μg/ml, the most antioxidant activity was reported at 84%, whereas at a minimal concentration of 20 μg/ml, the minimal activity was observed at 28%. Interestingly, the biosynthesized NiO-NPs showed better antioxidant activity (71%) at the optimal concentration of 60 μg/ml than the conventional medication (62%) [(Suresh et al., 2024)](https://paperpile.com/c/IkHjwO/zg0X3). The Mo doped NiO NPs showed a maximum inhibitory efficacy of 84.2%, as opposed to the 74.8% seen in NiO NPs at a concentration of 200 g/mL, according to the ABTS.+ scavenging assays. The NiO NPs and Mo doped NiO NPs demonstrated radical scavenging capabilities of 61.2% and 69.2%, respectively, for the hydrogen peroxide radicals at a concentration of 200 µg/mL. The Mo doped NiO NPs and NiO NPs underwent the reducing power assay as well. Comparing the doped NPs to the pure NPs (69.5%), the doped NPs showed superior reduction results of 78%. When it came to scavenging superoxide radical ions in the assay, Mo-doped NiO NPs (59.4%) performed better than NiO NPs (49.9%) [(Alam et al., 2023)](https://paperpile.com/c/IkHjwO/PTJk8).

# CONCLUSION

The research on the bioflavonoid mediated synthesis of nickel oxide nanoparticles provides promising results.The nanoparticles exhibited high efficacy in antimicrobial and antioxidant properties.Further research on this area should focus on evaluating the suitability of the nanoparticles to be used in various biomedical applications.

# FUTURE SCOPE

This research's future focus includes a number of interesting fields. To guarantee the biocompatibility and safety of the nanoparticles for medical applications, extensive in vivo and in vitro research is required. Additional research on targeted drug delivery methods may improve the effectiveness and accuracy of therapies utilizing nickel oxide nanoparticles mediated by bioflavonoids. Furthermore, a careful examination is necessary of the possible environmental uses, such as pollution management and water purification. To maximize the functioning and uses of nanoparticles, advanced characterisation techniques should also be used to improve the interaction mechanisms between nanoparticles and biological systems.

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