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ORIGINAL ARTICLE

To Employ Leaves of *Ficus carica* to Synthesize Green Fe_2O_3 Nanoparticles

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ABSTRACT

Every day, new nanoparticles are being created, and their properties are being examined since they exhibit significant differences from their original materials in both physical and chemical characteristics. There have been considerable developments in nanoscience regarding the creation of sustainable and environmentally friendly products. Iron oxide nanoparticles, which are a type of metal oxide nanoparticle, display various shapes and properties. Recently, iron oxide nanoparticles have been successfully produced from different plant species using eco-friendly synthesis methods, and their diverse bioactive properties have been explored. The green synthesis of iron oxide nanoparticles is a cost-effective, rapid, and environmentally safe approach compared to conventional synthesis methods. In this research, iron oxide nanoparticles were created using a completely safe method that involves Ficus carica leaf extract. The synthesized product was analysed using FT-IR and UV-Visible spectroscopy. Characterization methods indicated that the product was created in a mixed form with dimensions ranging from 43 to 57 nm. Furthermore, an assessment of the product's antioxidant activity revealed that the nanoparticle exhibits outstanding antioxidant, antibacterial, and photocatalytic properties.

Keywords: *Green synthesis; iron oxide nanoparticles; antioxidant activity; Ficus carica*

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INTRODUCTION

Nanoparticles have led to revolutionary developments in many scientific fields [1]. However, nanoparticle research is still a Nanostructures intense field as the products have various applications in different fields [2]. Metal oxide nanoparticles have attracted attention due to their unique and unusual physical and chemical properties [3, 4]. Furthermore, due to its important role, metal oxide nanoparticles are of outstanding importance in many fields such as materials chemistry, medicine, agriculture, information technology, biomedicine, optics, electronics, catalysis, environment, energy, etc. [5-12]. Reducing the size of nanoparticles increases the surface area, changes the magnetic, chemical and electronic properties and the properties of metal oxide nanoparticles [13]. For example, magnetite-type iron oxide nanoparticles have been used as contrast agents in magnetic resonance imaging and magnetic storage devices [14]. The 55 nm γ-Fe2O3 nanoparticle is ferromagnetic while 12 nm is superparamagnetic [15]. Therefore, with the desired size, the nanoparticles provide the expected magnetic, electronic, and chemical properties Iron oxide nanoparticles have been used in many fields since 1990, including medicine, biotechnology, the environment, and photocatalysts [16-18]. Magnetite and maghemite (Fe3O4 and γ-Fe2O3) involve different oxidation steps of iron and exhibit prominent physicochemical properties such as high surfaces usually require special equipment and high costs, but yields are low [23]. In addition, toxic, corrosive and flammable chemicals are used during the process, and the solvent and reducing agent waste produced after the synthesis procedure affects both the environment and human health [24, 25]. The shortcomings of these traditional methods can be overcome in a sustainable and environmentally friendly way by using natural precursors such as plants, bacteria, seeds and algae [26]. Green synthesis is based on the use of secondary metabolites extracted from natural initiators as reducing and stabilizing agents, first attempted by Anastas and Warner in 1998 [27]. The characteristics of nanoparticles vary depending on the type and composition of natural precursors (stems, cells, leaves, seeds, etc.), extraction methods, and extraction conditions [28, 29].

Several plant life had been attempted to synthesize metal or metallic oxide nanoparticles after which they were evaluated for particular application. One of such plants attempted for inexperienced synthesis of nanoparticles of various metals like Silver, gold, tin oxide, copper oxide, iron oxide, palladium, etc. are ***ficus carica*** [30]. In many cases, those metal nanoparticles had been explored for his or her packages in any segment of carried out science. So far, no such evaluation has been made for one of these unmarried plants, which has been attempted for synthesis of various metallic nanoparticles. *Ficus carica*, commonly called fig, is a deciduous plant of the Morus alba family. It grows naturally in Southwest Asian countries and the Mediterranean region. It is 15 to 20 feet high, has many branches, and is a secret milky white latex containing the protein hydrolase ficin. Its leaves are large, light green, lonely, alternating, with more or less deep leaves and 1-5 sinuses. The upper part is roughly hairy, and the lower part is soft and hairy. Flowers are like vessels (psychoniums) that originate in the axilla. Fruits are edible, with axillary, leafy branches, pear-shaped, and often cracked when ripe. The inner part of the fruit is a white inner ring containing a mass of seeds associated with the pulp of sweet jelly. There are many seeds and different sizes. The bark is smooth, silvery.

Fig: 1: *Ficus carica* Leaf (Fig)

Fig 2: *Ficus carica* Plant

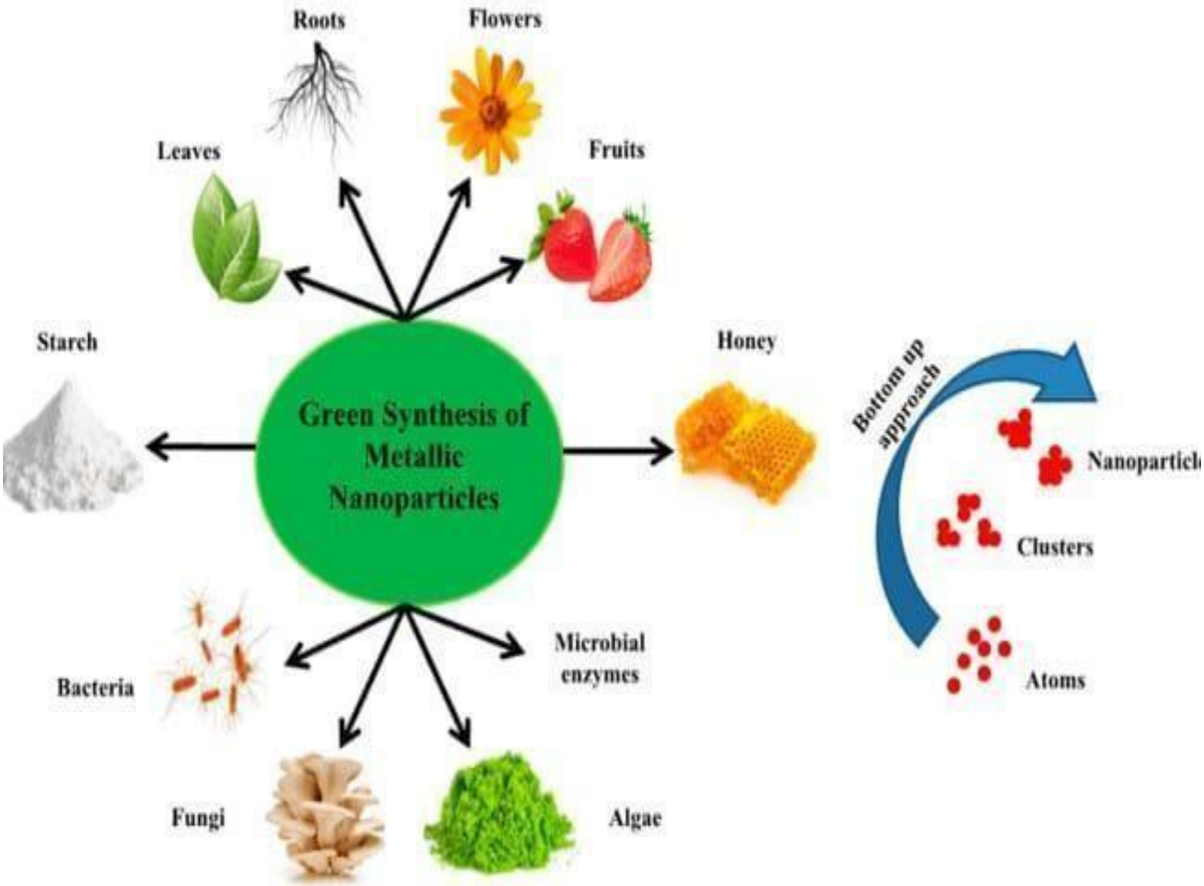


Fig 3: General Synthesis of Metallic Nanoparticles

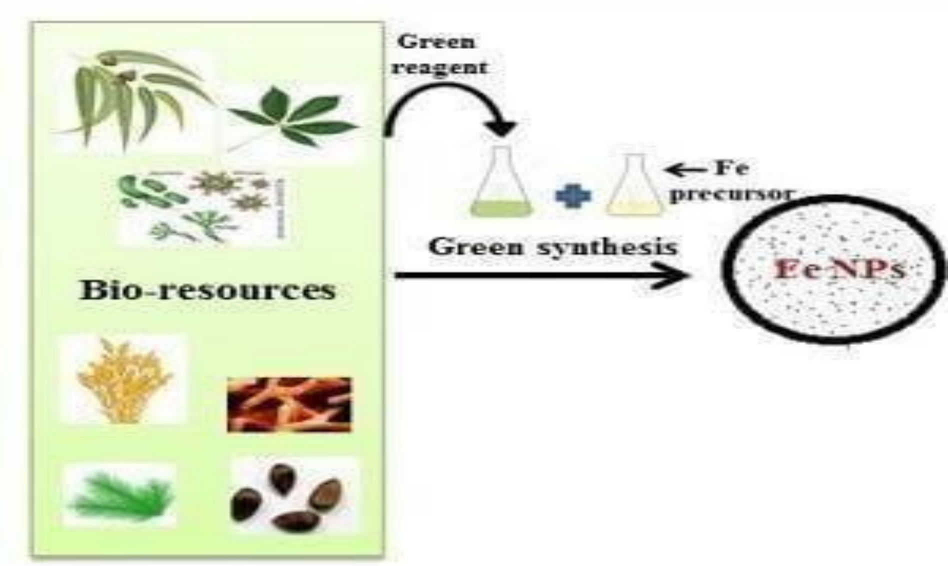


Fig 4: General Synthesis of Iron Nanoparticles

So, *ficus carica* could be a diploid species within the Moraceae family and has more than 1400 species isolated into approximately 37 genera [31]. Whereas natural products and clears out of *Ficus carica* have been utilized for human utilization for centuries, pharmacological properties of the distinctive parts of the tree have been as often as possible examined as of late [32-36].

Bioactivities of *Ficus carica* such as antiviral, antibacterial, antifungal, hypoglycaemic, and antimicrobial have been decided, and these properties and these are due to secondary metabolites such as flavonoids, phenolic compounds, phytosterols, fatty acids [37-39]. Athanasios et al. moreover famous the nearness of psoralen and bergapten in *Ficus carica* leaf [31]

In this study, iron oxide nanoparticles were synthesized by using fig leaf extracts and characterized by UV-visible spectroscopy, Fourier transform infrared spectroscopy (FT-IR).

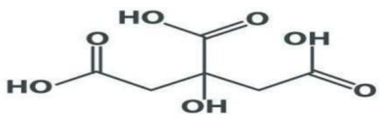
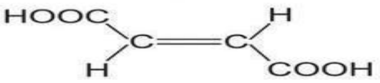
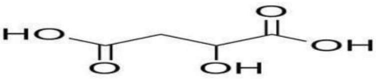
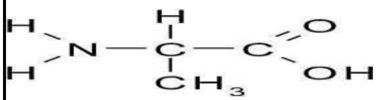
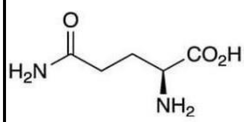
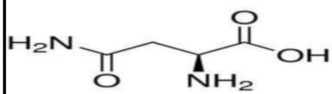
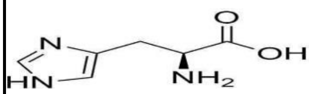
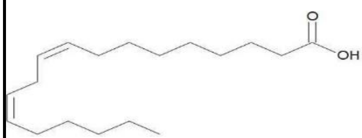
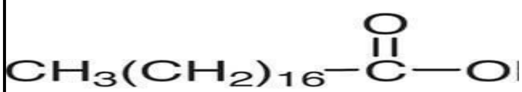
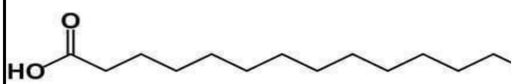
PHYTOCHEMICAL COMPOSITION

Phytochemical investigation carried out on *Ficus carica* has driven to the confinement of phytosterols, anthocyanins, amino acids, natural corrosive, greasy acids, phenolic components [40], hydrocarbons, aliphatic alcohols, unstable components, and few other classes of auxiliary metabolites from its distinctive parts.

Ficus carica biosynthesized a variety of plant metabolites (both primary and secondary) in its different organs. Oliveira and his co-workers have reported the presence of diverse phytochemicals from different organs of FC. In 2009, Oliveira et al. presented an organic acid profile of fig leaves, composed of: citric, fumaric, malic, oxalic, quinic, and shikimic acids.

On HPLC consider of FC latex, Oliveira et al. [41] uncovered the nearness of basic amino acids (phenylalanine, leucine, tryptophan, histidine and lysine)and eight non-essential amino acids (alanine, asparagine, glutamine, glycine, serine, tyrosine, cysteine, and ornithine); in any case on GC/MS investigation of FC latex, they claimed the nearness of numerous soaked, monounsaturated and polyunsaturated greasy acids like pentadecylic, myristic, margaric, palmitic, stearic, cis-10-heptadecenoic, linoleic, elaidic, arachidic, oleic, heneicosylic, behenic, lignoceric, andtricosylic acids. Alongside these phytocompounds, they too found few unstable standards like a-thujene, a-pinene, b-pinene, limonene, terpinolene, eucalyptol, cis-linalool oxidinalool and epoxylinalool (monoterpenes) and a-guaiene, a-bourbonene, bcaryophyllene, trans a-bergamotene, a-caryophyllene, germacrene D, cadinene and a-calacorene(sesquiterpenes). Takes off have been detailed to contain flavonoids like quercetin, luteolin, etc [42]. Some of the phytochemicals are listed in the Table 1.

Table 1: Phytochemicals present in *Ficus carica* plant

Phytochemicals	Structures
Citric Acid	
Fumaric Acid	
Malic Acid	
Oxalic Acid	
Alanine	
Glutamine	
Asparagine	
Histidine	
Linoleic Acid	
Stearic Acid	
Palmitic Acid	

AIM OF EXPERIMENT

Fig. 5: Experiment

Apparatus and materials :-

UV-Visible spectra and the Fourier Transform Infrared (FT-IR) spectra were recorded. Iron (III)chloride hexahydrate (97.0 %, FeCl3· 6H2O), sodium hydroxide (99.5 %, NaOH) was used for iron oxide nanoparticle preparation. All solutions were prepared using distilled water. All glassware was rinsed using distilled water and air-dried in a hot-air oven before using.

Extract preparation :-

Ficus carica leaves were freshly collected, washed twice and dried in a laboratory oven at 70°C for 2 days. The dried leaves were ground into fine particles using a laboratory grinder. 10 g of the finely divided leaf particles was dissolved in 200 mL of deionized water in a 500 mL flat bottom flask. It was heated and stirred in a water bath at 80°C for 1 hour. The aqueous leaf extract was filtered using filter paper, put into an amber bottle, and stored in the refrigerator [43].

Green synthesis of iron nanoparticles :-

2.70 g (0.01 M) of FeCl3.6H2O was weighed and dissolved with 100 mL of distilled water. The mixture was poured into a bottom flask and heated with a mechanical stirrer at 70°C. 40 mL of the plant extract was added in drops to the stirring iron solution. The pH of the mixture was altered to basic (pH of 11) using a few drops of 0.1 M NaOH. The mixture was stirred for 1 hour. The resulting product was isolated with the centrifuge, severely washed with ultrapure water to remove any unreacted salt and metabolites, and dried in the oven at 80°Celsius for one day [44, 45].

Fig. 6: Synthesized Iron Oxide Nano Particles

RESULT AND DISCUSSION

FT- IR Spectra :-

IR spectra of iron oxide nanoparticles were recorded and the spectra is shown in figure 7. Within the IR range of iron oxide nanoparticles, the band in 3251.61 cm^{-1} is considered hydroxyl, whereas the band in 2962cm^{-1} may well be considered as the sign of carboxylic acids. The carbonyl band is in 1628.2 cm^{-1}, whereas the band in 1072 cm^{-1} may be assessed as C-N. It has been clearly shown here that within the IR spectra of iron oxide nanoparticles, the groups between 400-570 cm^{-1} have been evaluated magnetite whereas maghemite has been recorded between 620-660 cm^{-1} and the groups on 470 cm^{-1} and 540 cm^{-1} are considered as hematite. Within the recorded IR range Figure, the groups recorded in 470 cm^{-1}, 501 cm^{-1}, 555 cm^{-1}, 594 cm^{-1} and 633 cm^{-1} might be the diverse shapes of iron oxide nanoparticles.

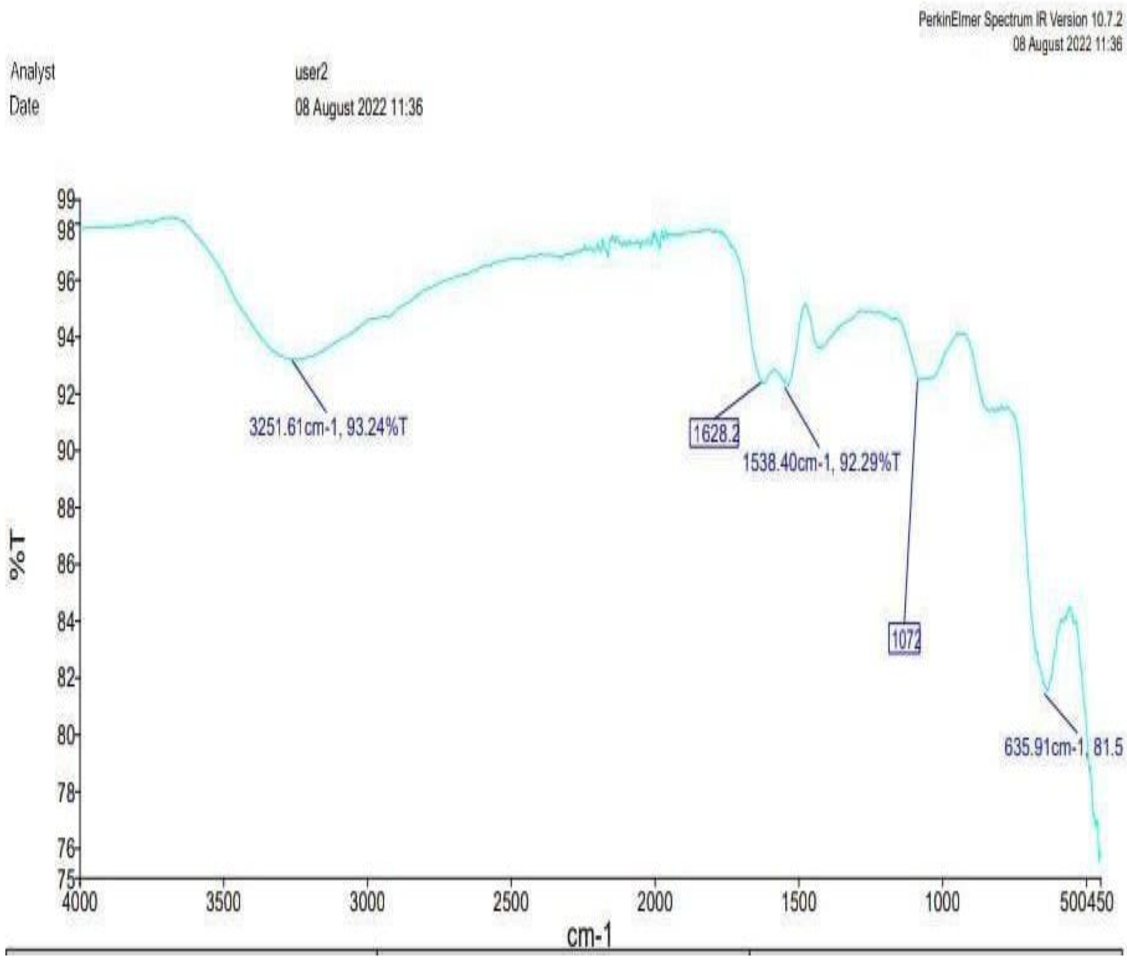


Fig. 7: FTIR Spectra of Iron Oxide Nano Partile

UV- Visible Spectra :-

UV-Visible spectra of iron oxide nanoparticles are presented below in figure 8. Here the sharp peak at 200 nm indicates the presence of iron oxide nano particles.

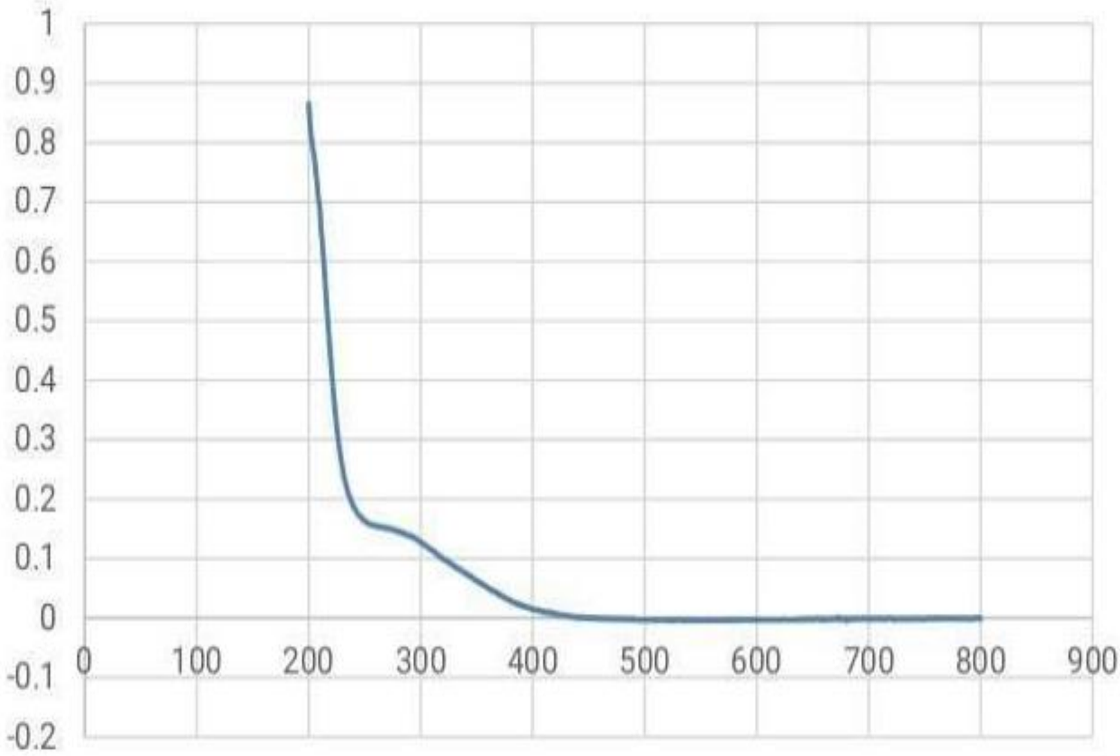


Fig. 8: UV- Visible Spectra of iron oxide Nano particle

APPLICATIONS

Antioxidant activity :-

The antioxidative activity of the resultant product as a nanoparticle can be determined by DPPH free radical scavenging activity.

To determine DPPH free radical scavenging activity of the nanoparticle, a certain weighable amount of it is added to DPPH (1,1-diphenyl-2-picrylhydrazyl) radical solution prepared in methanol and the mixture is left in the dark for 30 minutes. At the end of this period, the decrease in the amount of free radicals in the tube containing nano particles compared to the tube containing no nanoparticles can be demonstrated by measuring the absorbance The same experiment is also performed with standard antioxidant ascorbic acid. The rummaging exercises of both ascorbic corrosive and nanoparticles are calculated utilizing the taking after condition in percent. Hence, the DPPH free radical rummaging effectiveness of 1 gram of nanoparticles is communicated as ascorbic corrosive identical (mgAAE/g test).

Rummaging movement (%) = (Ablank-Asample)/Ablank x 100

In expansion, by performing the same test within the nearness of distinctive sums of nanoparticles, the sum of nanoparticles adequate to crush 50% of the radical within the environment is communicated as SC50

The DPPH method concluded that they had a surprising antioxidant action. Calculated DPPH tests can be utilized to assess the product's capacity to trap free radicals.

Antibacterial Activity

The well-diffusion method may employ to evaluate the antibacterial effects of iron nanoparticles on four human pathogenic Gram-negative (Escherichia coli, Salmonella enterica, and Proteus mirabilis) and one Gram-positive (Staphylococcus aureus) bacterial strains [48-50].

CONCLUSION

Many researchers have used *Ficus carica* leaf and extracts to synthesize metallic nanoparticles from source compounds by green and economic route. Various phytochemicals present in *Ficus carica* leaf act as both reducing and capping agent for both synthesizing and stabilizing nanoparticles of selected metal. Assume the confident advancements in nanoparticles are assessed. In that case, the amalgamation of nanoparticles from cheap and simple beginning materials and the special properties of each synthesized item will persuade forthcoming review. In this way of thinking, iron oxide nanoparticles were synthesized from dried *Ficus carica* cleared out and characterized and their antioxidant action was analysed. In follow-up thoughts, the analysts will proceed to synthesize nanoparticles with diverse metal forerunners from normal items. It is evident that green synthesized iron oxide nanoparticles ought to be examined with progressed ponders to be potential candidates in different biomedical applications much obliged to their antioxidant actions

Most of these metallic nanoparticles synthesized have proved to possess significant application in any scientific domain like antimicrobial activity of silver nanoparticles against Gram positive and negative bacteria and few fungal strains, accurate determination of mercury in water samples using stannic oxide nanoparticles and catalysis of Suzuki reaction by palladium nanoparticles coated reduced graphene oxide. It can be concluded that different & modern applications of *Ficus carica* plant extricates help synthesized metallic nanoparticles like dye reduction or use in photovoltaic cells can be determined.

FUTURE OUTLOOK

Based on this survey, future scope for the utilize of *Ficus carica* extract seem incorporate green amalgamation of nanoparticles of diverse metals like nickel, nickel oxide, zinc, zinc oxide, magnesium oxide and their assurance of their applications in both comparative and distinctive spaces (science, electrochemistry, environment, engineered chemistry).

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