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Paper Authors
Dharmasoth Rama Devia, Ganga Rao Battua, Keloth Basavaiah

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Plant mediated green synthesized Magnetite Nanoparticles (Fe3O4 NPs) for Antioxidant, antibacterial, Anticancer activities-A review

Dharmasoth Rama Devi[a*], Ganga Rao Battu[a], Keloth Basavaiah[b]

[a.] A.U. College of Pharmaceutical Sciences, Andhra University, Visakhapatnam-530 003, A.P, India.

[b] Department of Inorganic and Analytical Chemistry, Andhra University, Visakhapatnam-530 003, A.P, India.

AUTHOR INFORMATION

Corresponding Author

Dharmasoth Rama Devi- A.U. College of Pharmaceutical Sciences, Andhra University, Visakhapatnam-530 003, A.P, India; Phone: +919398912208; Email:ramajoy90@gmail.com

Authors

Ganga Rao Battu - A.U. College of Pharmaceutical Sciences, Andhra University, Visakhapatnam-530 003, A.P, India; Email:ganga.battu@gmail.com

Keloth Basavaiah- Department of Inorganic and Analytical Chemistry, Andhra University, Visakhapatnam-530 003, A.P, India; Email:klbasu@gmail.com

Abstract

The usage of various plant extracts for green synthesis of magnetite nanoparticles, these plant extracts gaining importance day today when compared to the physical and chemical methods of synthesis due to its various advantages such as low cost, biocompatible, biodegradable, non-toxic. They also act as both reducing and capping agents during the synthesis of nanoparticles and this association achieved various pharmaceutical, and other biomedical applications. this study investigates the Plant mediated green synthesized Magnetite Nanoparticles (Fe3O4 NPs) for Antioxidant, antibacterial, Anticancer activities.

Keywords: plant-mediated Magnetite Nanoparticles (Fe3O4 NPs), Antioxidant, Antibacterial, Anticancer activities.

Introduction

During the past decade Fe3O4 NPs have attracted much attention for technological applications due to their unique properties, such as being superparamagnetic (Mahdavian and Mirrahimi, 2010), biocompatible, biodegradable, and non-toxic to humans (Hu, F. Q *et al*., 2006; Zhao, H *et al*., 2009; Zhang, L *et al*., 2013). These unique properties allow Fe3O4 NPs to be widely used in different areas of applications, such as catalysis (Gawande *et al*., 2013; Sharad *et al*., 2014) magnetic storage media, (Terris and Thomson, 2005), biosensors, magnetic resonance imaging (MRI) (Kavitha *et al*., 2013; Haw *et al*., 2010) and targeted drug delivery (Qiao *et al*., 2009; Salem *et al*., 2015; Li, X *et al*., 2012; Wani *et al*., 2014).

Various methods have been

employed for the synthesis of Fe3O4 NPs such as sol-gel method (Lemine *et al*., 2012), solid-state synthesis (Paiva *et al*., 2015), and flame spray synthesis (Kumfer *et al*., 2010). Green synthesized Fe3O4 NPs can possess better characteristics, such as higher biocompatibility and biodegradability compared to physically synthesized Fe3O4NPs. Hence, they can be utilized in biomedical applications due to the special surface coating of green materials, which is not only non-toxic and biocompatible yet also allow targeted drug delivery with Fe_3O_4 NPs localization in a particular area. Toxicity towards the human body can be minimized because the green materials used for synthesizing Fe_3O_4 NPs are safe to be consumed and thus it would be beneficial in biomedical applications In contrast to the time-consuming chemical and physical methods which involve complicated procedures, the green method is much easier and safer to use, and especially plant-mediated synthesis of Fe_3O_4 NPs is a new and green method. The phytochemicals present in plants are capable of synthesizing crystalline Fe_3O_4 NPs. (Yuvakkumar and Hong, 2014) synthesized Fe_3O_4 NPs with particle size 100-200 nm from $Fe(NO_3)_2.6H_2O$ as precursor using peel waste extract of Rambutan as a green ligation and chelating agent. Valentin *et al.,* (Makarov *et al*., 2014) have prepared spherical shaped Fe_3O_4 NPs by using $FeCl_3$ $6H_2O$ as a precursor and aqueous extracts of *Hordeum vulgare* and *Rumex acetosa* plants as reducing and capping agents. Sathishkumar *et al*., have synthesized inverse cubic spinel structured, polydispersed and spherical shaped Fe_3O_4 NPs via co-precipitation method by using $FeCl_3.6H_2O$ as a precursor and an aqueous fruit extract of *C. guianensis* as reducing and capping agents for antibacterial activity and cytotoxic activity (Sathishkumar *et al*., 2018). Prasad *et al*., have synthesized Fe_3O_4 NPs from $FeCl_3$

$6H_2O$ using extract of watermelon rinds as a solvent and capping and reducing agent for catalytic activity (Prasad *et al*., 2016). Latha *et al*., have prepared orthorhombic structured spherical shaped Fe_3O_4 NPs from $FeCl_3.6H_2O$ using leaf extract of *Caricaya papaya* as reducing and capping agents (Latha and Gowri, 2014). Patra *et al*., have prepared Fe_3O_4 NPs via co-precipitation of $FeCl_2$ and $FeCl_3$ using an aqueous ear leaf *corn* extract for antioxidant and antibacterial activities (Patra *et al*., 2017). Khataee *et al*., (Khataee *et al*., 2017) have prepared Fe_3O_4 NPs by co-precipitation of $FeCl_3$ $6H_2O$ and $FeCl_2$ $4H_2O$ in presence of coffee waste hydrochar extraction as a capping agent. Lunge *et al*., have successfully synthesized cubic structured Fe_3O_4 NPs with the particle size ranges from 5-25 nm by precipitation of $FeCl_3$ $6H_2O$ in presence of tea waste template as capping agent (Lunge *et al*., 2014). Horst *et al*., have prepared Fe_3O_4 NPs by co- precipitation of 2:1 molar ratio of $FeCl_3{\cdot}6H_2O$ and $FeSO_4{\cdot}7H_2O$ using Gum Arabic as capping agent used for hyperthermia treatments (Horst *et al*., 2017). Niraimathee *et al* ., have prepared spherical shaped Fe_3O_4 NPs with an average particle size of 67 nm from $FeSO_4$ using an aqueous root extract of *Mimosa pudica* as a capping agent used for targeted drug delivery (Niraimathee *et al*., 2016). Buazar *et al*., have prepared Fe_3O_4 NPs with an average particle of 40 nm Fe_3O_4 NPs from $FeSO_4$ $7H_2O$ as the precursor using homemade starch-rich potato aqueous extract as the reducing agent and a stabilizing layer for the catalytic activity towards the removal of a methylene blue organic dye contaminant in wastewater (Buazar *et al*., 2016). Bahadur *et al*., have reported a modified co-precipitation method for the synthesis of water-soluble citric acid modified ultrafine superparamagnetic ferrofluid with 12 nm Fe_3O_4 NPs from $FeCl_3.6H_2O$ and $FeCl_2.4H_2O$ salts solution using hydrazine (N_2H_4) and sodium hydroxide in presence of lemon juice (Bahadur *et al*., 2017). Venkateswarlu *et al*., successfully synthesized spherical shaped Fe_3O_4 NPs with the particle size ranging from 9-20 nm from $FeCl_3$ $6H_2O$ as a precursor in presence of seed extract of *Syzygium cumini* (Venkateswarlu *et al*., 2014). Kumar *et al*., synthesized spherical shaped Fe_3O_4 NPs and with the average particle size of 54.5 ± 24.6 nm from $FeSO_4$ $7H_2O$ as the precursor using leaf extract of *Andean blackberry* (Kumar *et al*., 2016). Phumying *et al*., successfully synthesized crystalline and inverse cubic spinel structured Fe_3O_4 NPs with the particle size ranging from 6-30 nm by hydrothermal reduction of $(Fe(C_5H_8O_2)_3)$ as the precursor in presence of *Aloe vera* plant extract solution for targeted drug delivery (Phumying *et al*., 2013). Rajendran *et al*., synthesized crystalline and cubic structured Fe_3O_4 NPs with an average particle size from 25-60 nm from $FeCl_2$ as precursor using leaf extract of *Sesbania grandiflora* (Rajendran and Sengodan, 2017). Alavi, M., Karimi, N., & Valadbeigi, T. (2019) reported the antibacterial, antibiofilm, antiquorum sensing, antimotility, and antioxidant activities of green fabricated Ag, Cu, TiO_2, ZnO, and Fe_3O_4 NPs via *protoparmeliopsis muralis* lichen aqueous extract against multi-drug-resistant bacteria. Biswas *et al* ., *reported Mikania mikrantha* leaf extract mediated biogenic synthesis of magnetic iron oxide nanoparticles: Characterization and its antimicrobial activity study. *Materials (*Biswas *et al .,* 2021).

Table 2.3. Different sizes, shapes, and applications of synthesized Fe_3O_4 NPs by using plants

Plant name	**Part used**	**Size (nm)**	**Shape**	**Application**	**References**
Leucas aspera	Leaves	20	Irregular rhombic	antibacterial activity and antioxidant studies	Wani *et al.*, 2014
C. guianensis	Fruit	17	Spherical	Antimicrobial Cytotoxic activity	Paiva *et al.*, 2015
Caricaya papaya	Leaves	25	Spherical	Biomedical applications	Yuvakkumar and Hong, 2014
Syzygium Cumini	Seed	9–20	Spherical	bio-medicinal	Khataee *et al.*, 2017
Andean blackberry	Leaf	54.5	Spherical	Antioxidant activity	Lunge *et al.*, 2014
Amaranthus spinosus	Leaf	91-125	spherical shape with rhombohedral	photocatalytic and antioxidant activity	Muthukumar and Matheswaran, 2015

Sageretia thea (Osbeck)	Leaf	473	Rhombohedral	Antioxidant, antibacterial, Anticancer,	Khalil *et al.*, 2017
Grewia optiva and Prunus *persica* phyto species:	Leaf	15-60 and 13-70	Quasi-spherical and Spherical	antibacterial and antioxidant activity	Mirza *et al.*, 2018

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