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Green Synthesis of Iron Nanoparticles Using Green Tea leaves Extract

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Abstract

The interest in synthesizing Nanoparticles in an easy and environmental friendly way has been increasing in the recent years. Physical and Chemical methods are conventionally used for synthesis of Nanoparticles, however due to limitations of these methods, the focus of research has been recently shifted towards the development of clean and eco-friendly synthesis protocols. The green synthesis of Iron Nanoparticles has been achieved using environmental acceptable plant extract. It was observed that Camellia sinensis leaf extract can reduce Iron ions into Iron Nanoparticles at room temperature. The aim of this study is to synthesize Iron Nanoparticles using Camellia sinensis extract in an environmental and sustainable way. The synthesized Iron Nanoparticles were characterized using Scanning Electron Microscope (SEM) and Fourier Transform Infrared (FTIR) analysis. This study shows that the Iron Nanoparticles can be synthesized using Camellia sinensis leaf extract as a reducing agent.

Keywords: Green synthesis; Nanoparticles; Green tea leaves

Introduction

Nanotechnology can be defined as the manipulation of matter through certain chemical or physical processes to create materials with specific properties which can be used in various applications [1]. It is the ability to measure, manipulate and manufacture things on an atomic level usually between 1-100 nm. They have a large surface area to volume ratio which is their most important feature responsible for the widespread use of these Nanomaterials [2]. Physical and chemical methods are being extensively used for production of metal and metal oxides. Nanoparticles which requires the use of reactive and toxic reducing agents which may cause death and adverse effects on the environment and organisms [3]. Biosynthesis of Nanoparticles is a kind of bottom up approach where the main reaction occurring is reduction/oxidation [4]. With the antioxidant or reducing properties of plant extracts, they are usually responsible for the reduction of metal compounds into their respective Nanoparticles. Green synthesis provides advancement over chemical and physical method as it is cost effective, environment friendly, easily scaled up for large scale synthesis and in this method there is no need to use high pressure, energy, temperature and toxic chemicals [5]. Green synthesis offers better manipulation, control over crystal growth and their stabilization [6]. This has motivated an upsurge in research on the synthetic routes that allows better control of shape and size for various nano technological applications.

Nanoparticle can be synthesized in two following ways:

a) Bottom-Up Approach: In this approach atoms and molecules are assembled to form nanomaterials of required size and shape by controlled deposition or reaction parameters. The example of such approach is in the electronics industry in making Integrated Circuits (IC), sol-gel, etc.

b) Top-Down Approach: In this approach, the reverse mechanism is used where the atoms and the molecules are removed from the bulk material to obtain desired nanoparticle.

In nanotechnology Nanoparticles research is an important aspect due to its innumerable applications. Nanoparticles have expressed significant advances owing to wide range of applications in the field of bio-medical [7], sensors [8], catalysts [9], electronics [10], photocatalysis [11], etc.

Materials and Methods

The Green Tea leaves used was from a commercial tea vendor (Lipton green tea). The metal precursors used in this experiment were Ferric Chloride Anhydrous from Merck. In synthesis or solution preparation, de-ionised water used.

Preparation of green tea leaf extract powder-reducing agent

The extract of the tea was prepared by taking 20 g of tea in 1000 ml of de-ionised water. The solution was heated at 80°C in the water bath to get the tea extract. The extract was collected and filtered. The filtered solution was collected and stored in a clean, dried beaker for further use.

Synthesis of iron nanoparticles

The synthesis of Iron Nanoparticles was done by adding 0.01 M Ferric Chloride and the Green Tea leaves extract in 1:1 proportion in a clean sterilized flask (Figures 1a-1c).

The solution resulting from the addition of Green Tea extract and 0.01 M Ferric Chloride was black in color. There was an immediate color change after the addition of Green Tea extract to the Ferric chloride solution. The solution (c) was centrifuged and the supernatant was discarded and the pellet was washed with de-ionised water and was centrifuged again to remove any impurities (Figure 2).

Results

The Iron Nanoparticles were successfully synthesized in an easy and eco-friendly way using the Camellia sinensis leaves extract as a reducing agent.

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Discussion

Reduction mechanism of green tea

Green tea is taken as the reducing agent for the synthesis of the different morphology of iron oxide nanoparticles because it contains a high amount of polyphenols and other organic groups in it. It has been found out that about 4000 species are present out of which 1/3rd of the total is polyphenols that help in the reduction of the salt precursors to nanoparticles. The polyphenols consist of flavonoids and catechins. The catechins mainly the Epigallocatechin Gallate (EGCG) is the active catechin that take part in reduction process because it has a standard potential of 0.57 V that can thus reduce the Fe^{3+} to Fe0 as the standard potential of the iron is -0.036 V. The reduction mechanism takes place in two steps first when the precursor is added it first forms a complex by breaking the –OH bond and forming a partial bond with a metal ion. Secondly, there is breakage of the partial bond and the transfer of electrons to reduce the metal ions to nanoparticles, and thus itself get oxidize to ortho-quinone that has been shown in the Figure 3.

Characterization

The morphology and size were verified by characterizing the sample by FTIR and SEM analysis for studying the functional groups and diameter of the nano particles.

FTIR analysis of Green Tea extract and synthesized Iron nanoparticles was done to analyse and evaluate the attached biomolecules to the Iron nanoparticles. The FTIR of extract showed vibrations stretching at 1632 cm^{-1} for C=C and 3452 cm^{-1} for O-H. The C-H and C-N adsorption bands were also observed 2926 and 1383 cm^{-1}.

Comparing to that of the FTIR of the product(Iron Nanoparticles) it showed wide stretch of O-H group at 3419 cm−1, C=C at 1635 cm^{-1}, C-H at 2923 cm^{-1}, and C-O-C and C-N at 1020 and 1379 cm^{-1} which matches almost to that of the extract. The oxidized polyphenols on the synthesized Iron Nanoparticles were examined. It may be assumed that the polyphenols in the green tea extract may function as reducing agent as well as capping agent (Figures 4 and 5).

SEM images of iron nanoparticles

Average diameter of Iron Nanoparticles was found to be about 116 nm (Figures 6 and 7).

Conclusion

As a result of this study, Iron Nanoparticles were synthesized successfully in an easy and less time consuming way using Camellia sinensis leaves extract. The Polyphenols in Green Tea extract may possess the properties of reducing the ferric cations and also act as capping agents.

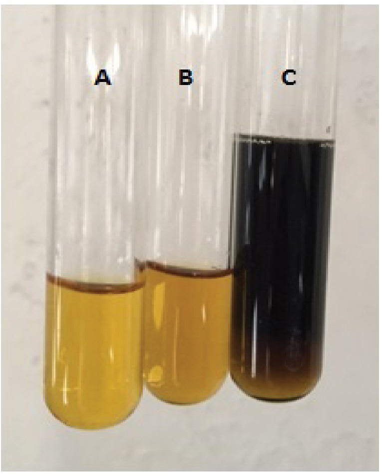

Figure 1: (a) Green tea extract, (b) 0. 01 M ferric chloride, and (c) Synthesized iron nanoparticles.

Figure 2: Black pellets sedimented during centrifugation showing the synthesis of iron nanoparticles.

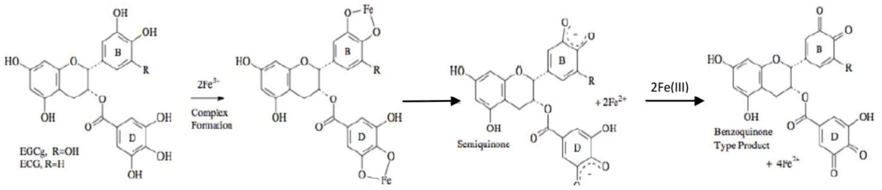

Figure 3: Two step mechanism of reduction of the iron salt precursor by green tea extract.

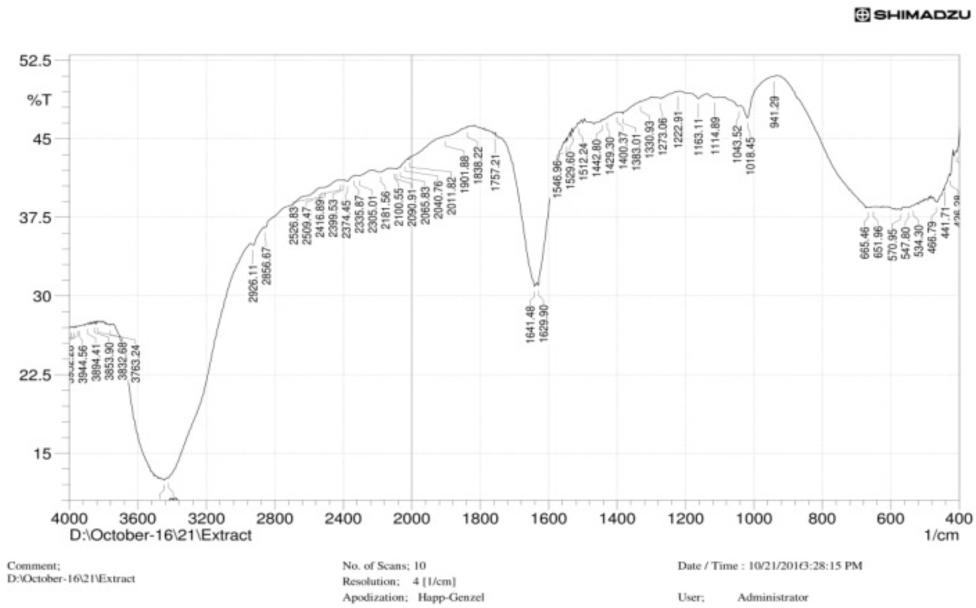

Figure 4: FTIR of extract.

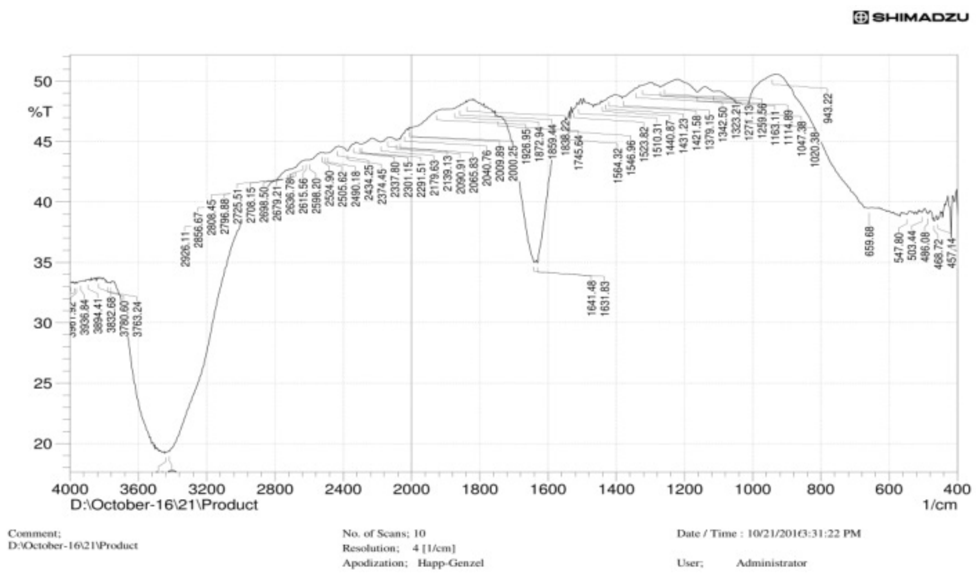

Figure 5: FTIR of product.

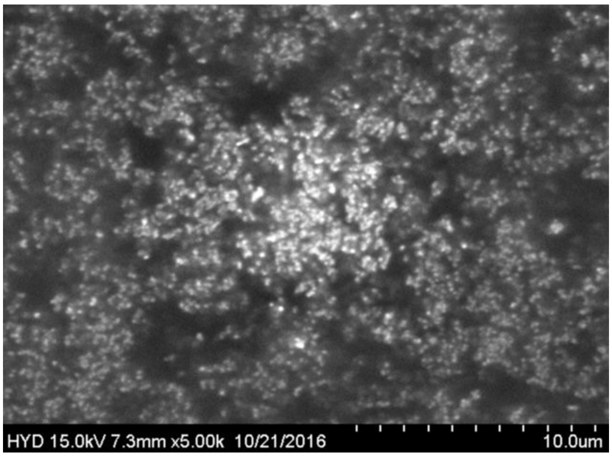

Figure 6: SEM image of iron nanoparticle.

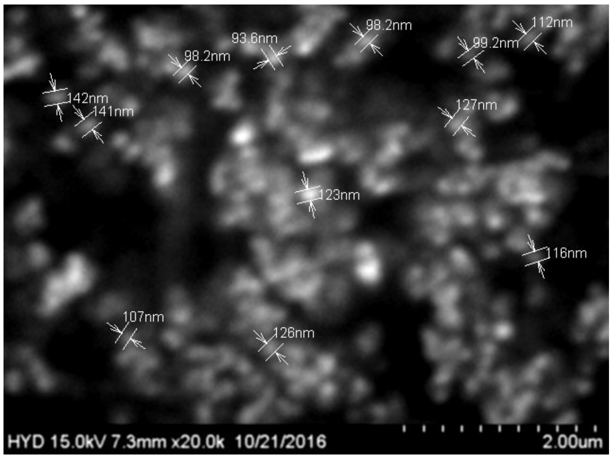

Figure 7: Zoomed SEM image of the iron nanoparticles.

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