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BIOSYNTHESIS AND CHARACTERIZATION OF ZERO-VALENT IRON NANOPARTICLES

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ABSTRACT

The synthesis of nanoparticles has become a matter of great interest in recent times due to their various advantageous properties in variety of fields. The exploitation of different plant materials for the biosynthesis of nanoparticles is considered a green technology because it does not involve any harmful chemicals. In the present work, nano scaled zero valent irons (nZVI) were synthesized from the plant extract of under atmospheric conditions. The iron nanoparticles obtained are mainly in zero valent oxidation state. Characterization of nZVI was performed systematically by using UV, XRD studies. The diameter of iron nanoparticles was predominantly found within the range 50-100 nm.

KEYWORDS: zero valent ironnanoparticles, green synthesis, UV, XRD.

1. INTRODUCTION

A nanoparticle can be defined as a microscopic particle that has atleast one dimension less than 100 nm in size[1]. Nanotechnology is mainly concerned with synthesis of nanoparticles of variable sizes, shapes, chemical compositions and controlled dispersity and their potential use for human benefits. Nanotechnology is a growing field in which the understanding and control of matter in the nanometer scale is used to develop new solutions. Unique physical properties of molecule at 1-100 nanometer scale make novel application possible. Nanoparticle show completely new or improved properties, such as size, distribution and morphology of the particles etc. Novel applications of nanoparticles and nanomaterials are emerging rapidly on various fields[2]. Nanotechnology is a reliable and enabling environment friendly process for the synthesis of nanoscale particles.

Nanoparticles are being used in adsorption processes for water purification. Impurities adsorb on nanoparticle metal oxides with high sorption capacities and have gained increased

attention among researchers for environmental remediation. A number of reports have shown that nano-sized sorbents such as elemental iron, titanium oxide, and iron oxide are more effective compared to their macro-sized[3-6]. The advantages of nanomaterial chemistry with respect to conventional technologies usually in cases of adsorption, surface sites of the adsorbent particles are more frequently utilized (as bulk diffusion is kinetically hindered in the absence of porous structure). The surface-to-volume ratio increases drastically with pthe reduction of the size of the adsorbent particle from bulk to nano dimensions. It leads to the availability of higher numbers of atoms/molecules on the surface for adsorption of contaminants.

Physical and chemical methods are being used extensively for production of metal nanoparticles. however, this production requires the use of very reactive and toxic reducing agents which cause undesired detrimental impacts on the environment, plant and animal life it supports. Use of biological organisms such as microorganisms, plant extractor plant biomass could be an alternative to chemical and physical methods for the production of nanoparticles in an ecofriendly manner[7-9]. Plant mediated biological synthesis of nanoparticles has gained importance only in the recent years[10].

The need for environmental non-toxic synthetic protocols for nanoparticles synthesis leads to the developing interest in biological approaches which are free from the use of toxic chemicals as byproducts. Thus, there is an increasing demand for "green nanotechnology"[11]. Many biological approaches for both extracellular and intracellular nanoparticles synthesis have been reported till date using microorganisms including bacteria, fungi and plants[12, 13]. Green synthesis provide 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[1]. The biological molecules undergo highly controlled assembly for making them suitable for the metal nanoparticle synthesis which was found to be reliable and eco friendly[14]. Iron nanoparticles (nZVI) have been mostly synthesized using different plant extracts. Plantextract act as low-cost reducing and stabilizing agents. Plant extract reduce the metal ions in a shorter time as compared to microbes.

In the present study we have performed the synthesis of green iron nanoparticles usin tea leaves extract. Aqueous ferric chloride solution, after reacting with tea leave extract, led to rapid formation of highly stable, crystalline iron nanoparticles. The rate of nanoparticle

synthesis was very high, which justifies use of plant over microorganisms in the biosynthesis of metal nanoparticle through greener and safer methods.

2. MATERIALS AND METHODS

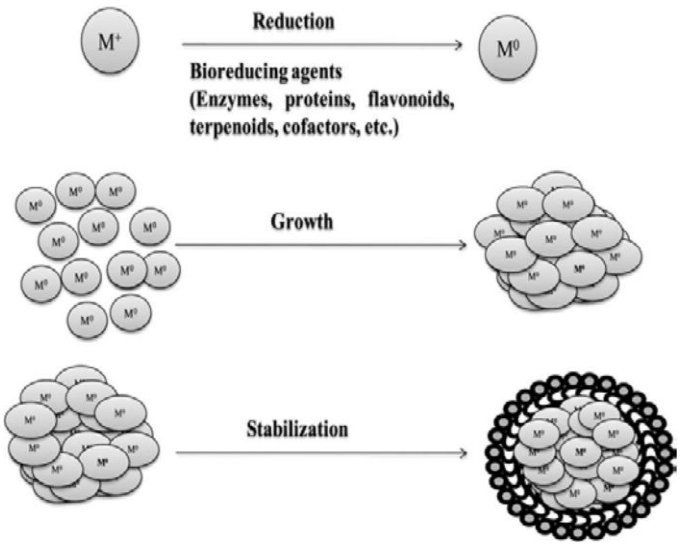
2.1 Reagents and chemicals

1. 0.01M $FeCl_3$ solution
2. Distilled water
3. Tea leaves

2.2 Green method of synthesis of zero valent iron nanoparticle(nZVI)

The synthesis of nZVI utilizing tea leaves extract containing a range of polyphenols. Without the addition of any surfactant or polymer, the stable nanoparticles were obtained at room temperature. Polyphenols in plant act as both reducing agent and a capping agent, resulting in stable green nanoscale zero valent iron nanoparticles with unique properties.

Iron nanoparticles are prepared by adding 0.1M $FeCl_3$ solution to the tea extract (prepared from 200 mg of tea leaves) in 1:2 volume ratio. The mixture was hand shaken and allowed to stand at room temperature for 1 hr. the colour of the solution changes from pale yellow to black indicating the formation of iron nanoparticles. Figure below illustrates general mechanism for synthesis of nanoparticles using plant extracts.



2.3 UV-Vis Spectroscopy

Visual observations of the changes in the reaction mixtures were recorded.

The wavelength was scanned from 200 to 700 nm. The instrument was switched on and allowed to initialize for ten minutes.The sample solutions were put in a Quartz cuvette (1cm) and the baseline corrected using ultra-purified water as the blank before carrying out a new experiment. The spectra of tea leaves extract, Fe nanoparticles and Ferric chloride solutions were obtained in the wavelength range of 200 and 700nm.

2.3 XRD technique

Crystalline metallic Iron nanoparticles were examined by PAN analytical Xpert Pro θ-2θ powder X-ray diffractometer. The instrument used a Cu Kα radiation at 45 kV with a monochromatic filter in the range of 20-80 degrees. The biosynthesized FeNPs were thoroughly dried to powder form before being stacked in the cubes of XRD equipment.

3. RESULTS AND DISCUSSION

In this experiment tea Leaves extract is used to produce Iron Nanoparticles. Fe^{+3} ions were reduced into Fe^{0} nanoparticles. After the reduction an immediate change in color from Light yellow to Black and change in pH of the solution is observed. It is known that Ferric Chloride exhibit bright yellowish color in distilled water. On mixing the plant extract with the aqueous $FeCl_3$ solution it changed the color of the solution immediately and reducing the pH, which is an indication of formation iron nanoparticles.

3.1 UV-Vis Spectra Analysis

The reduction of pure Fe^{+3} ions to Fe^{0} was monitored by measuring the UV-Vis spectrum by sampling of aliquots of Fe nanoparticle solution by dilution the sample in distilled water.

UV-Vis spectral analysis was done by using UV-Vis spectrophotometer systronics 118 at the range of 200-600 nm and observed the absorption peak at 216-268 nm regions.

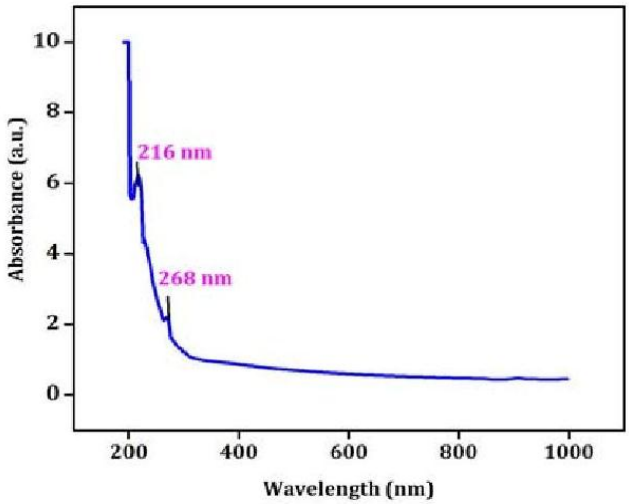


Fig. 1: a) -Iron Nanoparticle at 216-268 nm.

3.2 X-Ray diffractometer analysis (XRD)

The XRD analysis shown in figure indicates that the synthesized Fe nanoparticles were amorphous with weak characteristic peak of iron, implying the non-crystalline nature of the iron nanoparticles.

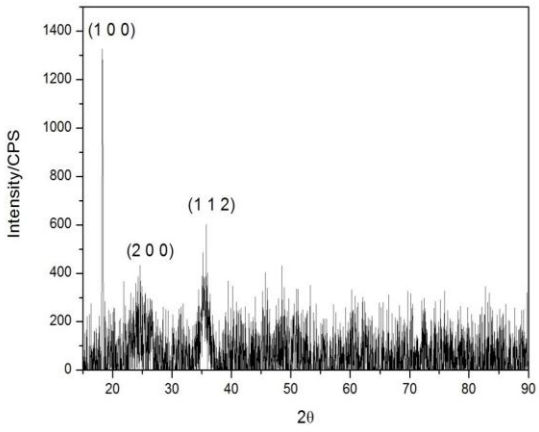


Fig. 2: XRD pattern of Iron Nanoparticles.

4. CONCLUSION

The biological synthesis of zerovalent iron nanoparticles using tea leave extract provides an environmental friendly, simple and efficient route. The characterization of the nanoscale zero-valent iron was performed using UV-Vis Spectroscopy and powder X-Ray diffractometer (XRD). From the UV-visible wavelength nanoparticles show quite good surface plasmon resonance behavior. X-Ray diffraction (XRD) investigations of the nZVI reavealed that the nanoparticles were amorphpus in nature with crystal planes at (110), (200)

and (112) characterstic for iron nanoparticles. Thus, the green synthesis using Tea leave extracts can be economic and effective method for the synthesis of zero-valent iron nanoparticle.

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