GREEN ROUTE SYNTHESIS OF IRON NANOPARTICLES AND ANTIBACTERIAL STUDIES

1NISHIGANDH S. PANDE, 2DIPIKA KAUR JASPAL, 3ARTI MALVIYA, 4JAYACHANDRAN V. P.

1Symbiosis Institute of Research and Innovation (SIRI), A Constituent of Symbiosis International University (SIU), Symbiosis Institute of Technology (SIT), Lavale, Pune-411015, Maharashtra State, India
2Symbiosis Institute of Technology (SIT), Symbiosis International University (SIU), Gram: Lavale, Tal. Mulshi, Pune-412115, Maharashtra INDIA
3Lakshmi Narain College of Technology, Bhopal-462021, Madhya Pradesh, INDIA
4Antibacterials and Microbial Technology Lab, Pushpagiri Research Centre, Pushpagiri Institute of Medical Sciences, Tiruvall-689101, INDIA

Abstract - Eco-friendly synthesis of iron nanoparticles was achieved by a novel, facile green route method using Abelmoschus esculentus as a reducing and capping agent. The successful formation of iron nanoparticles has been confirmed by X-ray diffraction, UV-visible, FTIR, FE-SEM and TEM analysis. The prepared nanoparticles have been tested for antibacterial activity for Escherichia Coli (Gram negative) and Staphylococcus aureus (Gram positive).

Keywords - Antibacterial Study, Ecofriendly Synthesis, Iron Nanoparticles, Natural Binder.

I. INTRODUCTION

Nanoscience is an upcoming topic of interest in the field of materials chemistry. Optimization of the synthesis parameters to obtain nanomaterials in the size range of 1-100 nm and the investigation of properties is the area covered under nanoscience. Nanoscale materials show size dependent properties different from the corresponding bulk or molecule. Recent researches have been focused towards the synthesis of these nanoparticles by eco-friendly methods.

Nanocrystalline iron particles, a topic of interest in the present research, have found various applications in several research areas such as biomedicine[1], catalyst [2], batteries [3], sensor [4], biomolecular detection [5] etc. In the last few years, various synthesis techniques have been developed to produce iron nanoparticles such as electrochemical synthesis [6], laser pyrolysis technique [7], chemical reduction [8] etc. The main concentration nowadays is to develop economical and environmentally clean synthesis methods to synthesize iron nanoparticles. Numerous ecofriendly materials have been used for synthesis of iron nanoparticles like plant extracts [9] etc. for the same. These eco-friendly techniques do not require high temperature, pressure or the use of toxic chemicals. In the present research paper, such an ecofriendly synthesis method for iron nano particles has been reported using the solutions of FeCl₃ and FeSO₄ by the aqueous extract of a natural material Abelmoschus esculentus. The nanoparticles synthesized by the mentioned ecofriendly method were found toxic for bacteria like Escherichia Coli (Gram negative) and Staphylococcus aureus (Gram positive).

II. METHOD OF ANALYSIS

Materials
FeCl₃, FeSO₄, used for the synthesis were analytical grade (Aldrich chemical). All the aqueous solutions were prepared with deionized water.

Synthesis of Iron nanoparticles
Solution of 0.05 M FeSO₄ and 0.025 M FeCl₃ solution were prepared in deionized water. 70 mL of the vegetable extract of Abelmoschus esculentus (Okra) was mixed with 10 mL of 0.05 M FeSO₄ and 0.025 M FeCl₃ solution in the sonocator at a temperature of 60 °C. The formation of yellow to dark green colour was observed indicating the formation of nanoparticles.

Antibacterial study
Weighed amount of HIMEDIA was dissolved in 500 ml of distilled water. The pH of the medium was adjusted to 7.4 by using 1N NaOH. The medium was heated to dissolve agar and to form a clear liquid. Distilled water was added to make final volume. It was sterilized in autoclave at 121 °C, 15 lb pressure for 15 minutes. The flask was allowed to cool up to 50 °C and then the medium was quickly poured into sterile plates under aseptic conditions. The medium was allowed to cool so as to produce solid agar plates.

The plates were inoculated by specific microorganism by spread plate technique and allowed to dry; wells were made by using sterile pipette. Test solution of specified concentration was then added in the well by using sterile pipette and the plates were then kept in freeze for 1 hour for diffusion followed by incubation at 37 °C for 24 hours.
III. RESULTS AND DISCUSSIONS

UV-visible spectra

The UV-vis spectra of iron nanoparticles synthesized by Abelmoschus esculentus (okra) extract is shown in figure 1. An absorption peak observed at 415 nm\([10]-[11]\).

After the addition of Ferrous sulphate (FeSO\(_4\)) and Ferric chloride (FeCl\(_3\)) solution, the colour of the solution changes from faint yellow to green indicating the synthesis of iron nanoparticles in the aqueous medium\([12]\).

![UV-visible spectra of Iron nanoparticles](image1)

X-ray diffraction

The formation of iron nanoparticles using Abelmoschus esculentus extract was further confirmed by X-ray diffraction (XRD) analysis. The observed peak at \((2\theta) 41.23^\circ\) was attributed to the 113 plane, which exhibited good crystallinity. A broad peak indicated the size in nano scale, which matches with standard JCPDS number 87-1164 \([16]-[17]\). The particles size was determined using Scherrer’s formula, \(D= 0.9\lambda/\beta\cos\theta\) was estimated at 24nm.

![X-ray diffractogram of Iron nanoparticles synthesized from Abelmoschus esculentus (okra) extract.](image2)

FTIR measurements of Ag-nanoparticles with Abelmoschus esculentus (Okra) showed the presence of bands at 582, 982, 1041, 1122, 1200, 1367, 1565,1769, 2902, 3259 and 3510 cm\(^{-1}\) (figure 2). The bands at 1565 and 1367 cm\(^{-1}\) corresponded to C-C and C-N stretching respectively indicating the presence of ligands similar to those found in biopolymers (proteins, carbohydrates) \([13]\).

The region of 3600-3100 cm\(^{-1}\) showed band is corresponding to –OH stretching vibration. C-H stretching vibration due to the presence of CH and CH\(_2\) was observed at 2902 cm\(^{-1}\). C=O stretching vibration was well represented at 1769 cm\(^{-1}\).

Anti-symmetrical deformation of C-O-C resulted in a peak at 1122 cm\(^{-1}\)\([14]\). Fe-O bond observed at 582 cm\(^{-1}\)\([15]\).

![FTIR absorption spectra of Iron nanoparticles binded with Abelmoschus Esculentus (okra) extract.](image3)

Field emission scanning electron microscopy (FE-SEM)

FE-SEM analysis results of iron nanoparticles were clearly distinguishable at different enlargements. Iron nanoparticles in the Abelmoschus esculentus extract (natural polymer) were found to be polydispersed (figure 5) and measured in size from 24 to 34 nm.

![Field emission scanning electron microscopy (FE-SEM)](image4)
Transmission electron microscopy (TEM)
Iron nanoparticles size was found between 20 to 34 nm, which nearly matched with the TEM (figures 6-10) as well as XRD results. The selected area electron diffraction pattern (SAED) studies showed the nanocrystalline nature and corresponded to the interplanar distances of 1.17 Å, in good agreement with the planes (113), for spherical iron nanoparticles (figure 11)[18]-[21].
IV. ANTIBACTERIAL ACTIVITY

The iron nanoparticles showed antibacterial activity against strain of gram negative and gram positive bacteria, which was effective against Escherichia Coli and Staphylococcus aureus respectively. The plates were examined after 24 hours of incubation and zone of inhibition was measured at 37°C. Iron nanoparticles solution with concentrations 500 µg/mL and 250 µg/mL were added for investigating the activity of Escherichia Coli and Staphylococcus aureus respectively, using a micropipette. The diameter of the zone to the nearest millimeter across the well was recorded. The results obtained after 24 hours has shown in table 1.

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Bacteria</th>
<th>Zone of inhibition(mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>E.coli</td>
<td>19</td>
</tr>
<tr>
<td>2</td>
<td>S.aureus</td>
<td>15</td>
</tr>
</tbody>
</table>

V. COMPARISON OF RESULTS

Iron nanoparticles showed antibacterial activity against pathogenic E. coli and S. aureus at concentration around 9 mg/mL and 3 mg/mL respectively.

Based on previously reported results of E. coli and S. aureus, here in proved antibacterial activity gave positive results at low concentration [22]-[23].

CONCLUSIONS

Iron nanoparticles were synthesized successfully by using Abelmoschus esculentus (natural polymer). The Iron nanoparticles were spherical as confirmed by TEM technique.

The size of iron nanoparticles ranged from 24 to 34 nm. Iron nanoparticles showed good antibacterial activity against E.coli and S.aureus.

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REFERENCES


