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Green Synthesis of Silver Nanoparticles Using Apple and Banana Peel Extract, Their Characterization and Optimization

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ABSTRACT
Since last decade, green synthesis of metal nanoparticles such as silver nanoparticles is emerging as a new path to stand against various infections. The present study aims to synthesize silver nanoparticles by a green biological route, using an extract derived from apple (AE) and banana peel waste (BPE), which acts as a reducing and capping agent for reduction of Ag^+ into Ag^0 derived from silver nitrate ($AgNO_3$) showing development of reddish-brown and yellowish-brown colour respectively. Process of synthesis was optimized using several parameters. Optimum concentration of $AgNO_3$ was found to be for AE: 1.25mM; BPE: 0.75 mM, concentration of extract for AE: 500 µl; BPE: 200 µl, pH was for AE: 9.0 and BPE: 9.0, temperature for AE: 50° C and BPE: 50° C and incubation period for AE: 96 hr; BPE: 24 hr for optimum synthesis of silver nanoparticles. Characterization of the synthesized nanoparticles with UV-Visible spectroscopy reveals a characteristic absorption of surface plasmon resonance (SPR) peak at 422 nm and 422.4 nm respectively. Fourier transform infrared spectroscopy (FT-IR) affirmed the role of AE and BPE as reducing and capping agent of silver ions.
Keywords:- Silver nanoparticles, Green synthesis, Characterization, FTIR.

I. INTRODUCTION

Nanotechnology (sometimes abbreviated to "nanotech") is the study of manipulating matter on an atomic and molecular scale. Generally, nanotechnology deals with structures sized between 1 to 100 nanometre in at least one dimension, and involves developing materials or devices within that size (Kahn et al.,2006). Nanomaterials are leading circumference of the rapidly developing field of nanotechnology. They are attracting gradually because of their unique physicochemical properties, determined by their dimensions, shape, composition and crystallinity. They were employed for the treatment of water, in catalysis, field of medicine and biotechnology etc. Among synthetic nanomaterials so far produced, the metallic nanoparticles (NPs) have distinctive properties like conduction of electricity, catalysis, high stability for chemicals and antimicrobial activities (Muzaffar and Tahir et al.,2018).Among all metal nanoparticles, Silver nanoparticles (AgNPs) are important materials that have been studied extensively, such nanoparticles possess unique electrical, optical as well as biological properties and are thus applied in catalysis, bio sensing, imaging, drug delivery, nano device fabrication and in medicine (P. K. Jain, Huang, El-Sayed, and El-Sayed et al.,2008; Nair and Laurencin et al.,2007). As Silver is a nontoxic, safe inorganic antimicrobial agent that is capable of killing about 650 types of disease causing microorganisms there is an increasing interest in silver nanoparticles on account of the antimicrobial properties that they exhibit (Jeong, Yeo, and Yi et al.,2005). The plants or plants extract, which act as reducing and capping agents for nanoparticles synthesis, are more advantageous over supplementary biological processes since they are cost-effective, eco-friendly (Valli and Vaseeharan et al.,2012).According to the literature survey, many reports were present on biosynthesis of silver nanoparticles from plant extracts but only few reports were present on the biosynthesis of silver nanoparticles from waste plant products. The present study aims to synthesize silver nanoparticles by a green biological route, using an extract derived from banana peel waste and apple, and characterization of the synthesized nanoparticles utilizing UV-Visible spectroscopy and Fourier transform infrared spectroscopy (FT-IR) analysis.

II. METHODS AND MATERIAL

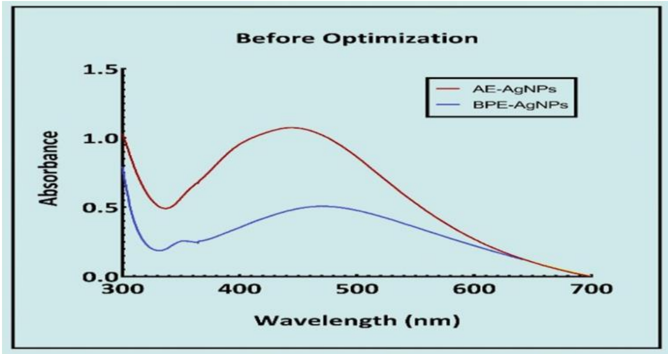
- **Preparation of Apple Extract (AE): -**
  100 g of apples measured, chopped into pieces and washed by tap water. Apple pieces were mixed up with deionized water which was heated to 75° C. Extraction was completed at a room temperature within a duration of an hour. The extract was refrigerated at 4°C for further use (Kazlagić et al., 2020).
- **Preparation of Banana Peel Extract (BPE): -**
  100 g of Banana peels were washed, boiled in deionized water for 30 minutes at 90° C. Peels were crushed in Mortar and Pestle with 100 ml deionized water and extract was filtered through cheese cloth. Filtrate was treated with chilled acetone (1:1 ratio of filtrate: acetone) and resultant precipitate was centrifuged at 1000 rpm for 5 minutes. Precipitate was resuspended in deionized water and refrigerated at 4° C for further use (Ibrahim, 2015).
- **Synthesis of silver nanoparticles using AE/BPE: -**
  The source of silver used was silver nitrate (SD Fine).Typical reaction mixtures contained 0.5 ml of AE in 4.5 ml of silver nitrate solution (1 mM in deionized water). The reaction mixture was incubated for 24 hrs. in the dark at 30°C to avoid the photo activation of silver nitrate under static conditions. AE as well as silver nitrate solution (1 mM) were used as control. Same protocol was followed for synthesis of silver nanoparticles using BPE as reducing agent and control (Ibrahim, 2015).
- **Effect of various parameters on synthesis of Silver Nanoparticle(AgNPs):-**
  The effect of the $AgNO_3$ concentration on synthesis of AgNPs was determined by varying the $AgNO_3$ concentration (0.25, 0.5, 0.75, 1.0, 1.25 mM). Similarly, the effect of AE concentration was also determined by varying its concentration (100, 200, 300, 400, 500 µl) while keeping the AgNO3 at a fixed concentration of 1.25 mM. The effect of pH was studied by adjusting the pH of the reaction mixtures to 5.0, 6.0, 7.0, 8.0 and 9.0. To study the effect of temperature on nanoparticle synthesis, the reaction mixtures containing 1.25 mM concentration of $AgNO_3$ and AE 500µl at definite pH (9.0) were incubated at 50, 60, 70, 80, 90°C for 5 min. The effect of incubation period was evaluated by incubating the reaction mixtures with optimum composition for 24, 48, 72 and 96 hr. Same protocol was followed for optimization of silver nanoparticles using BPE while keeping the AgNO3 at a fixed concentration of 0.75 mM.
- **Characterization of pre optimized and optimized Reaction mixture containing Silver Nanoparticle:-**
  The UV-Visible spectra of reaction mixtures containing AgNPs of both extracts were recorded individually. UV-Visible spectrometer (Shimadzu UV 1800) operated at resolution of 1nm with deionized water using as a blank over the range of 300-700 nm on basis of literature available. Post

optimized reaction mixtures were subjected to FTIR analysis using FTIR spectrophotometer (Bruker ATR Mode) having spectrum scanned in range of 500-4000 cm^{-1} for identification and assigning them to determine different functional groups present on the AgNPs.

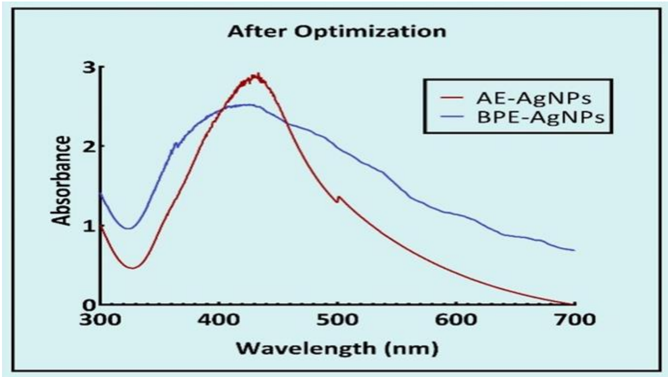
III. RESULTS AND DISCUSSION

The effect of different parameters on synthesis of AE-AgNPs and BPE-AgNPs was studied. Optimum concentration of $AgNO_3$ for AE and BPE was found to be 1.25 mM and 0.75 mM respectively. Similarly, optimum concentration of extract for AE-AgNPs and BPE-AgNPs was found to be 500 µl and 200 µl respectively. Optimum pH and Temperature for both reaction mixtures were 9.0 and 50^{o} C respectively, while optimum incubation period for synthesis of AE-AgNPs and BPE-AgNPs was found to be 96 hrs and 24 hrs respectively.

Silver nanoparticles are known to exhibit a unique optical property known as Surface Plasmon Resonance (SPR). Fig.1 (a) shows characteristic absorption peak at 444.7 nm and 471.7 nm for AE-AgNPs and BPE-AgNPs respectively.Fig.1 (b) shows characteristic absorption wavelength of 422.4 nm and 422 nm for AE-AgNPs and BPE-AgNPs respectively. FTIR measurements were also carried out to identify the major functional groups on the AE and BPE surface and their probable involvement in synthesis of silver nanoparticles. The spectra of AE-AgNPs in Fig.2 showed bands at 3319.96, 2892.06, 2118.47 and 1637.76 cm^{-1} were assigned to OH or N-H of carboxylic acid or amide, C-H stretching for CH2 and CH3 of alkane, C#C stretching of alkyne and C=O stretching of aromatic amides respectively. Similarly, BPE-AgNPs spectra in Fig.3 showed bands at 3286.90, 2118.76 and 1637.50 cm^{-1} were assigned to OH or N-H of carboxylic acid or amide, C#C stretching of alkyne, C=O stretching of aromatic amide and aliphatic amide.



(a)



(b)

Fig.1 – UV Visible absorption spectra of apple extract-silver nanoparticles (AE-AgNPs) and banana peel extract-silver nanoparticles (BPE-AgNPs); (a) before optimization, (b) after optimization.

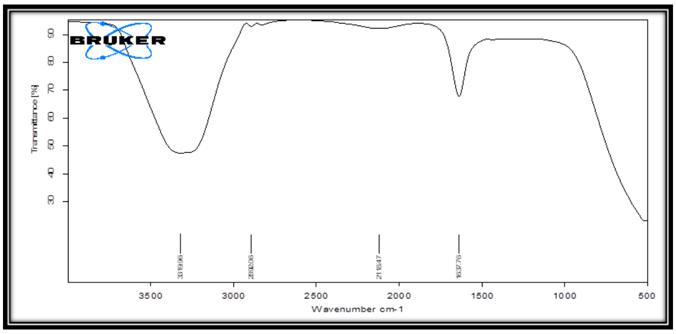


Fig.2 – FTIR spectra of AE-AgNPs after optimization

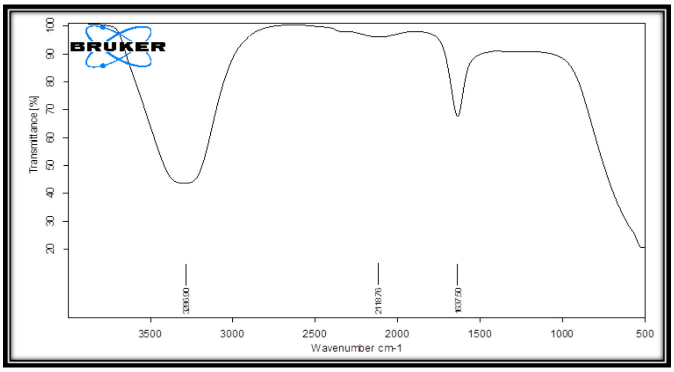


Fig.3 – FTIR spectra of BPE-AgNPs after optimization

IV. CONCLUSION

AE and BPE were successfully utilized as reducing and capping agent for the green synthesis of silver nanoparticles. Silver nanoparticles were characterized by UV-Vis spectrophotometer for confirmation of SPR which is further characterized by using FTIR spectrometer affirming role of AE and BPE as reducing and capping agent of silver ions.

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