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SYNTHESIS OF SILVER NANOPARTICLES FROM SELECTED PLANTS EXTRACT

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Abstract: Plants extract from Chromolaena odorata (C. odorata), Jatropha curcas (J. curcas) were used for the synthesis of nanomaterials from silver nitrate solution. The synthesized nanoparticles were characterized by UV, XRD and FTIR technique. The average particle sizes were found to be 3.58 nm, 3.64 nm corresponding to C. odorata, J. curcas, respectively. The plant extracts were also found to be good reducing agents for production of silver nanoparticles.
Keywords: nanoparticles; synthesis; FTIR; XRD; extracts

INTRODUCTION

Research on new materials technology is attracting the attention of researchers all over the world with the view to improving the properties of the materials [1]. Nanotechnology is a broad interdisciplinary area of research, development and industrial activity which has grown very rapidly all over the world for the past decade [2]. Nanotechnology is emerging as a rapidly growing field with its application in science and technology for the purpose of manufacturing new materials at the nanoscale level [3]. Different physical and chemical approaches are known for the synthesis of nanomaterials. Most of the methods reported in the literature are extremely expensive and also involve the use of toxic, hazardous chemicals such as stabilizers which may pose potential environmental and biological risks.

Recently, plants have been gaining importance due to their unique constituents and their diverse applicability in various fields of research and development [4]. The green synthesis of metallic nanoparticles and their applications is one of the most important area of research.[5,6] Plant extracts comprise of a wide range of naturally occurring chemical compounds, which are generally recognized as natural products .These natural products possess varieties of biological activities due to their exceptional variety in their chemical structures. The phytomolecules present in plant extracts enable the synthesis of the nanoparticles by acting as reducing agents. Also, it encourages the synthesis to be carried out under a control pressure and temperature. This advantage coupled with its environmentally-friendly nature and the fact that it does not require sophisticated laboratory facilities or costly instruments succeeds it as the best approach for synthesizing the nanoparticles directly accessible to be applied in several applications, particularly biological and catalytic applications [7]. In the present study, we have explored the synthesis of silver nanoparticles from the leaves extract of Chlomolaena odorata, Jatropha curcas.

MATERIALS AND METHODS

— Plants Extract Preparation

Each of Chromolaena and Jatropha, in Figure 1 and 2 were obtained in Akure, Ondo State, Nigeria, sundried and pulverized separately with a pulveriser with model number ES-1731F, power of 300W, frequency of 50Hz and an AC voltage of 220V. About 10g of each of the pulverised leaves were weighed and soaked separately in 200ml distilled water and refluxed in a water bath. The mixture was then filtered to obtain the extracts [8].

Figure 1. Chromolaena odorata

Figure 2. Jatropha curcas

— Biosynthesis of silver nanoparticles

The stocks of extracts obtained were used for preparing the nanomaterials by the addition of 0.1M of $AgNO_3$. The mixture containing the $AgNO_3$ was then placed in a microwave oven for complete bioreduction at a power of 300W for 10minutes [4] while the colour change was being monitored with the naked eye.

— Characterization of silver nanoparticles

To characterize the silver nanoparticles, the following tests were conducted;

— UV–Vis spectra analysis

The reduction of pure silver ions was monitored by measuring the UV–Vis spectrum of the reaction medium at 5 h after diluting. A small aliquot analysis was done using UV–Vis spectrophotometer UV-2450 (Shimadzu).

— X-ray diffraction (XRD) analysis

The AgNP solution was repeatedly centrifuged at 5000 rpm for 20 min, re-dispersed with distilled water and lyophilized to obtain pure AgNPs pellets. The dried mixture of AgNPs was collected to determine the formation of AgNPs. This was carried out using Shimadzu XRD-6000/6100 model with 30 kV, 30 mA with Cukα radians at angle 2θ.

— FTIR

The AgNPs obtained were centrifuged and redispersed and subsequently, the dried powder was obtained by lyophilizing the purified suspension. The resulting lyophilized powder was examined by Infrared (IR) spectra, recorded on a Bruker Vector-22 Infrared spectrophotometer using KBr pellets.

RESULTS AND DISCUSSIONS

— Visual Examination

The leaf extract had a pale yellow colour and appeared thick and muddy soon after adding $AgNO_3$. After the solution was kept in the microwave oven, the intensity of the colour increased gradually from pale yellow to dark brown at the end of the experiment. The appearance of dark reddish brown colour is an indication that the aqueous silver ions in the reaction mixture were reduced to silver nanoparticles [9]. A steady state was achieved where there was no significant change after some time, therefore indicating the completion of the reduction reaction process. The appearance of the brownish colour was due to the excitation of Surface Plasmon Resonance of the AgNPs [10]. The free electrons of AgNPs give rise to a surface plasmon resonance absorbance due to the combined vibration of electrons of the metal NPs in resonance with the light waves [8]. Thus, indicating the reduction of Ag+ to Ag^0 of the AgNPs.

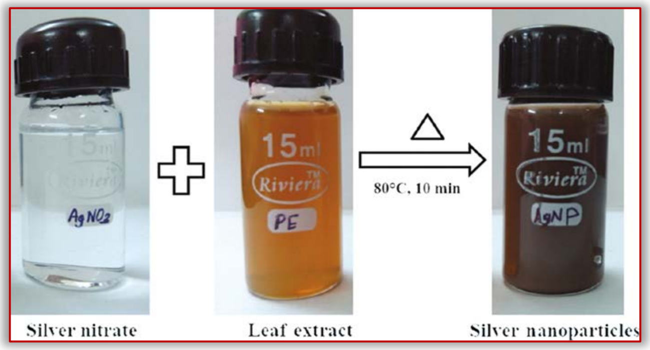

Figure 3: Pictorial Representation of the Synthesis of the Nanomaterials Showing the Colors of the Reactants and the Product

— UV-Vis Analysis

The formation and stability of silver nanoparticle in aqueous colloidal solution were confirmed using UV–Vis spectral analysis. Figures 4 and 5 show the UV-Vis absorption spectra of the leaf extract and synthesized silver nanoparticles solution of C. odorata, J. curcas respectively. Numerous intense absorption peak are observed in the range of 200 to 260 nm for the leaves extract while for the AgNPs, the peaks are in the range of 250 to 400 nm corresponding to the surface plasmon resonance of silver nanoparticles. This peak pattern is similar to the result of Narender et al. 2013 [11].

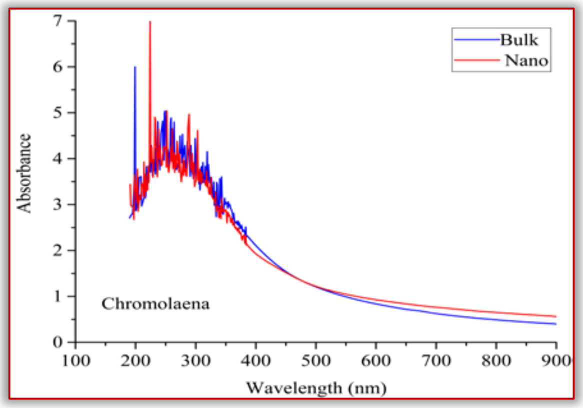

Figure 4: UV-Vis Absorption Spectra of C. odorata Leaf extract and C. odorata Synthesized Silver Nanoparticles Solution

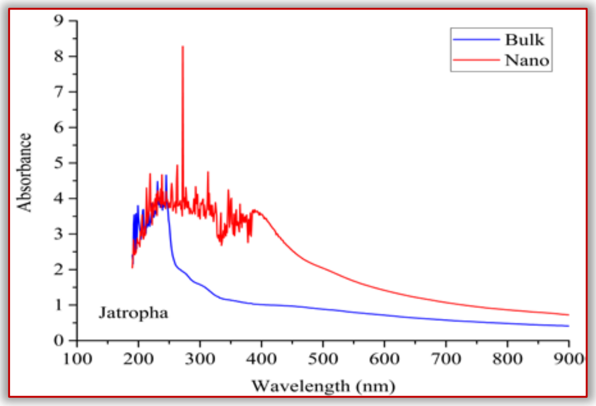

Figure 5: UV-Vis Absorption Spectra of J. curcas Leaf extract and J. curcas Synthesized Silver Nanoparticles Solution

— X-Ray Diffraction Studies

In order to verify the results of the UV–vis spectral analysis and to determine the nature of the silver nanoparticles, the samples of silver nanoparticle in aqueous colloidal solution were examined by XRD. Figure 6 and 7 show the XRD pattern for silver nanoparticles synthesized using natural plants extract. The particle size of silver nanoparticles was calculated from the XRD pattern according to the line width of the plane [4]. The equation uses the reference peak width at angle θ, where λ is the X-ray wavelength (0.154060 nm), β is the width of the XRD peak at half height and κ is a shape factor. The calculated particle size of the biosynthesized AgNPs were found to be 3.58 nm and 3.64 nm corresponding to C. odorata, J. curcas respectively.

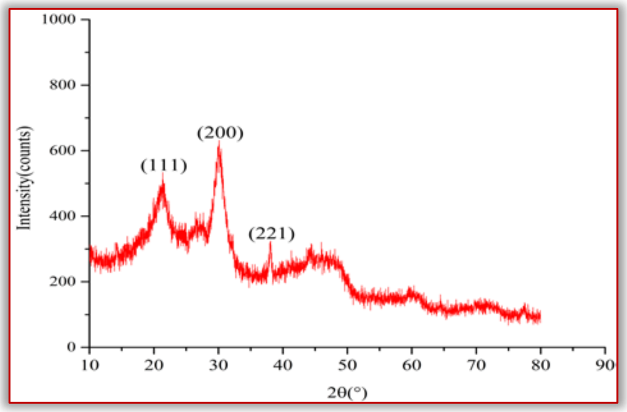

Figure 6: XRD Pattern of the Silver Nanoparticles of C. odorata Extract

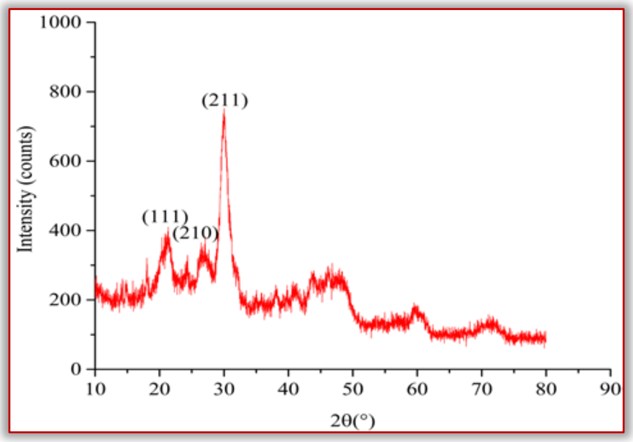

Figure 7: XRD Pattern of the Silver Nanoparticles of J. curcas Extract

— FTIR Analysis

FTIR spectroscopy was employed to characterize and identify the biomolecules of leaves extract of C.odorata, J. curcas. FTIR spectra of C. odorata leaf extract and synthesized C. odorata AgNPs solution are shown in Figure 8. The spectrum of the C.odorata extract contains an absorption peak at 3428 cm^{-1} indicating the presence of hydroxyl groups, which points to the existence of several oxygen comprising functional groups, such as carboxylic, epoxy, carbonyl, and hydroxyl groups.

Other absorption peaks were observed at 2939, 2830, 1984, 1550, 1185 and 1006 cm^{-1}, due to vibration and deformation bands of C-H stretch, C=C and C-O stretch respectively. Most of the absorption bands of the C.odorata also exist in the FTIR spectrum of C.odorata AgNPs, either at identical positions or with minor shifts, for instance the band at 3388, 2931, 2838, 1542, 1263 and 1077 cm^{-1}. The presence of these IR bands in the spectrum of C.odorata AgNPs evidently recommends that the organic compounds of C.odorata extract not only act as a bioreductant, but also act as capping ligands on the surface of the C.odorata AgNPs. Shaik et al., 2017 [12] reported similar observation on Origanum vulgare leave extract.

FTIR absorption spectra of Jatropha leaf extract before and after bioreduction, are shown in figure 9. The major absorbance bands present in the spectrum of the Jatropha extract were at 3419, 2915, 2846, 1557 and 1433 cm^{-1} .The broadband observed at 3419 cm^{-1} could be assigned to stretching vibrations of O–H groups in the leaf extract. The bands at 2915 and 2846 cm^{-1} correspond to stretching vibrations of CH group. The sharp peak at 1557 and 1433 cm^{-1} could be assigned to carbonyl group. While the spectrum of the reduced Jatropha L.extract showed characteristic absorbance bands at 3404, 2923, 2861, 2349, 2015, 1550 and 1426 cm^{-1}, respectively. In the IR spectrum of nanoparticles, shifts in the band peaks from 3419 to 3404, 2915 to 2923 and 1557 to 1550 cm^{-1} corresponding to OH, CH and carbonyl group respectively with decreased band intensity were observed. Based on these band shifts, it can be inferred that both hydroxyl and carbonyl groups of Jatropha L. extract are involved in the synthesis of silver nanoparticles [13].

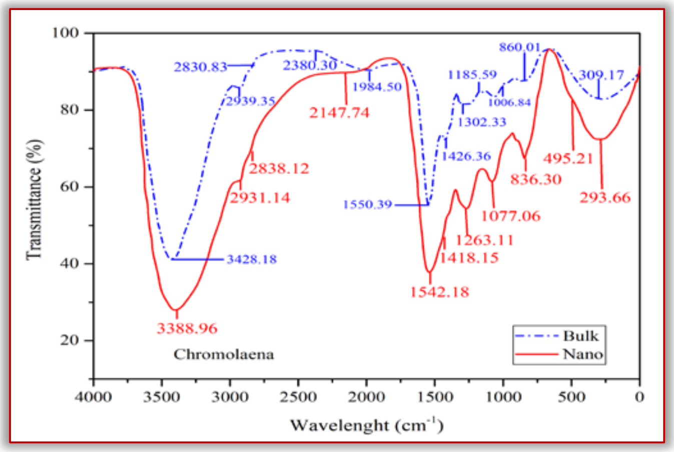

Figure 8: Fourier Transform Infrared Spectroscopy Spectra of C. odorata Extract

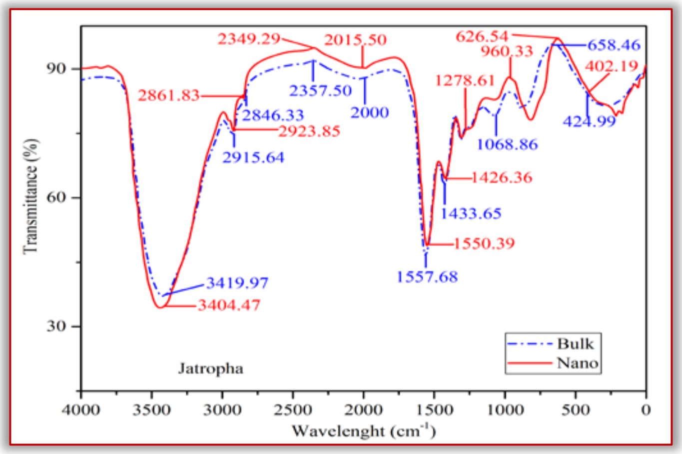

Figure 9: Fourier Transform Infrared Spectroscopy Spectra of J. curcas Extract

CONCLUSIONS

Synthesized nanomaterials from plants extract were investigated. From the results of the analyses, the following conclusions were drawn;

- C. odorata, J. curcas were good reducing agents for silver metal. This is evident from the appearance of reddish brown colour on the addition of $AgNO_3$ to the plants extract.
- The UV spectra of extract after the addition of $AgNO_3$ showed maximum absorbance at around 250 to 400 nm confirming the formation of AgNPs while the extract without the addition of $AgNO_3$ show low peak between 200 to 260 nm indicating that the plant extract is free from Ag^+ ions.
- The particle size of silver nanoparticles as calculated from the XRD pattern were found to be 3.58 nm, 3.64 nm corresponding to C. odorata, J. curcas respectively.

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