Phyto Production of Manganese Nanoparticles using Stubborn Grass (*Eleusine indica)* – A Preliminary Study

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Abstract

The production of nanoparticles from biomass is known to be a low-cost technique and also generates purer products in an environmentally friendly manner. This study investigated the manganese sorption capabilities of some plants that grow on manganese stockpiles and selected one with high manganese content as material for the production of manganese nanoparticles (MnNPs). The plants, including *Centrosema pubescens*, *Mimosa pudica, Stubborn grass* (*Eleusine indica)* and *tiwa* (local name) were harvested from manganese stockpiles at the Ghana Manganese Corporation. The plant extracts were obtained and manganese in solution was determined by Atomic Absorption Spectrometry (AAS). Stubborn grass (*Eleusine indica)* had manganese content of 68 mg/g while others had manganese content below 30 mg/g. Manganese nanoparticles were produced from extracts of stubborn grass. The manganese nanoparticles were characterized by the UV-Vis spectrophotometry. The UV-Vis spectrophotometry indicated a maximum absorbance of 2.343 at a wavelength of 230 nm.

Keywords: Hyper-accumulators, Sorption, Nanoparticles

1. Introduction

Nanotechnology is an emerging interdisciplinary science that has engrossed growing fondness in the research arena primarily for its desirable properties (Hoseinpour and Ghaemi, 2018). Nanoparticles have applicable ductility, high yield strength, hardness, flexibility and quantum size in comparison to its bulk composition (Annu *et al*., 2019; Iravani, 2011) with potential application in the electronic, optical and biomedical fields.

Manganese nanoparticles (MnNPs), the subject of this study, holds great promise in pushing the frontiers of nanotechnology and have been proposed to potentially replace technologies based on scarce elements such platinum catalytic convertors for cars (Veeramani *et al*., 2013). Due to its privileged physical and chemical properties, MnNPs have been put to a variety of uses including molecular sieves, solar cells, batteries, catalysts, magnetic materials, supercapacitors, optoelectronics, drug delivery ion-sieves, magnetic storage devices and water treatment and purification (Jayandran *et al*., 2015; Kumar *et al*., 2017; Sinha *et al*., 2011; Zhang *et al*., 2017). Additionally, they are less toxic materials in comparison with other compounds that makeup well known nanoparticle types (Hoseinpour and Ghaemi, 2018; Veeramani *et al*., 2013).

Traditionally, physico-chemical methods employed in the synthesis of nanoparticles have met widespread acceptance due to their ability to produce large quantities of nanoparticles in a short period of time (Abou El-Nour *et al*., 2010; Amooaghaie *et al*., 2015). However, these methods of production are expensive and require the use of toxic chemicals coupled with issues of stability, control of growth and aggregation of particle (Amooaghaie *et al*., 2015). Additionally, it is reported elsewhere that engineered nanoparticles can have adverse effect on humans, animals and plant (Abou El-Nour *et al.*, 2010; Quester *et al*., 2013). This warrants the need for a 'greener' and economical method to produce these nanoparticles. Phyto-production is one of the prevailing methods suggested as a valuable alternative for such physico-chemical methods (Jha *et al*., 2009). The direct production of nanoparticles by plants also eliminates the need for a separate pure metal production and synthesis stage.

The insitu, cost effective and environmentally friendly benefits of Phyto-production draws its application from the ability of plants to extract metals and metalloids from low grade ores and tailings (Khanlarian *et al*., 2020). These metals are adsorbed by the roots of plants and transported into harvestable plant tissues (Aderholt *et al*., 2017). Although a number of plants have metal-sorption abilities, particular species of plants called hyper-accumulators are desirable. This class of plants are able to accumulate extremely high levels of metals in their tissues to concentrations as high as 100 times more than normal plants (Ali *et al*., 2013).

The Ghana Manganese Corporation has several manganese stockpiles that sit for long durations and creates favorable conditions supporting plant growth. These plants depend solely on the manganese stockpile for nutrients and eventually sorb manganese during the process. Thus, the aim of this study is to investigate the sorption capabilities of the different plant species; *Centrosema pubescens*, *Mimosa pudica*, *Stubborn grass* (*Eleusine indica)* and *tiwa* (local name) that grow on the stockpile. The production of manganese nanoparticles from higher accumulators amongst the species of plants was also investigated.

2. Materials and Methods

2.1 Materials

Centrosema pubescens, *Mimosa pudica*, Tiwa and Stubborn grass (*Eleusine indica*) were harvested from the Ghana Manganese Company stockpile for use. The plant species are presented in Fig. 1. Analytical grade nitric acid and hydrochloric acid used were from Alfa Aesar.

(a) (b)

(c) (d)

Fig. 1 Plants harvested from the manganese ore stockpile (a) *Mimosa pudica* (b) *Centrosema pubescens* (c) Stubborn Grass (*Eleusine indica*) (d) Tiwa (local name)

2.2 Digestion and AAS Analysis

An initial investigation was conducted to estimate the amount of manganese in each of the plant samples. Each plant species was dried in the sun for two weeks to remove moisture and then ashed. The product obtained after ashing was subjected to acid digestion. A given mass of the ashed plants were weighed and digested with aqua-regia for 30 minutes. The filtrate was topped to 100 mL with distilled water. Manganese in solution was determined using the Varian AF 220 Fast Sequential AAS.

2.3 Plant Extract Preparation

The initial analysis indicated that stubborn grass had the highest concentration of manganese. Thus, further investigations were concentrated on this plant. Plant extract of stubborn grass was prepared by chopping the plant into fine pieces and weighing out 50 g. This was transferred into a 1 L conical flask, topped with water and heated with 500 mL of distilled water for 30 minutes. The extract obtained was filtered through Whatmann No.1 filter paper to remove insoluble materials and macromolecules. The resulting filtrate was heated to dryness to produce powdered plant extract which was analysed using the UV-visible Spectrophotometry analysis.

3. Results and Discussion

3.1 Manganese sorption

From the AAS analysis, stubborn grass (Eleusine indica) recorded the highest mass (68.05 mg) of

Manganese in 1 g of biomass. Centrosema pubescens recorded Mn value of 27.44 mg, the second after Stubborn grass. Manganese oxide (source of biomass for all grasses used) is known to be basic (alkaline) in nature. This condition may have affected the sorption capability of the plants and hence the low mass recorded. Mimosa pudica and Tiwa recorded 19.37 mg and 18.38 mg respectively. Fig. 2. shows the graphical representation of the amount of manganese in the various plants. This proves that among the four prominent plants, stubborn grass has a higher ability to sorb more manganese from its environment.

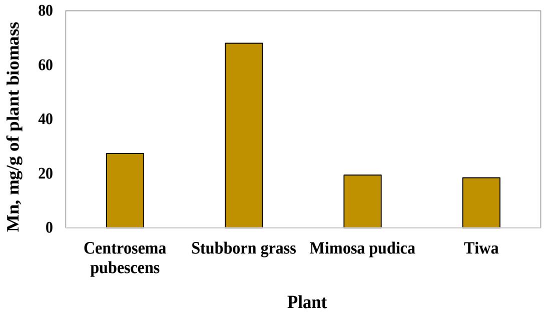

Fig. 2 Concentrations of Mn in each of the plants

3.2 Ultraviolet-Visible Spectra Studies

Ultraviolet-Visible Spectrophotometry is one of the prominent techniques for characterizing nanoparticles. Metal nanoparticles in aqueous solution can be determined by the UV-Visible spectroscopy. Fig. 3. shows the ultraviolet-vis spectra of manganese metal nanoparticles. It was observed that the maximum absorbance (amount of light absorbed by a sample at a specific wavelength) occurred at 230 nm. Fig. 3. shows that the absorbance value (2.343) was maximum at a wavelength of 230 nm. Work done by Jayandran *et al* (2015) identified manganese nanoparticles at 360 nm which indicates that there was a shift in wavelength in this study. The shift in wavelength to 230 nm has been observed by other researchers (Shukri *et al.*,2016: Ngo. *et al.*, 2015) and they attributed it to coatings on the surface or the size of the nanoparticle.

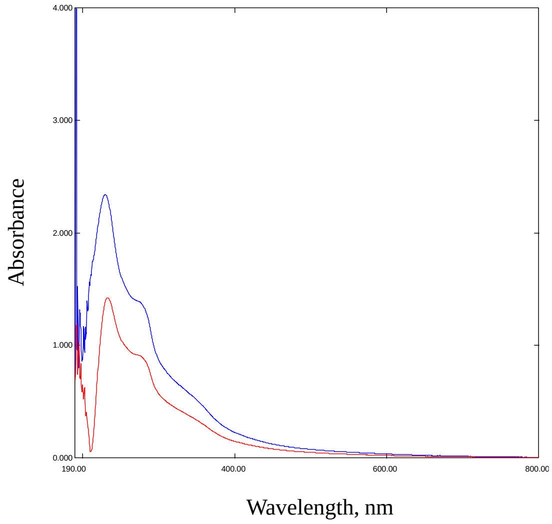

Fig. 3 Ultraviolet-Visible Spectra of Manganese Nanoparticles

4. Conclusions

After an initial assessment of four plants that grow on a manganese stockpile, stubborn grass (*Eleusine indica)* was seen to have the highest manganese content of over 65 mg per gram of biomass and it was selected for further study in the production of manganese nanoparticles. Manganese nanoparticles produced were examined using UV-Visible spectrophotometry. UV-Vis spectrophotometry which was used to identify the presence of nanoparticles indicated that high amount of light was absorbed at a wavelength of 230 nm. From the UV-vis spectra studies, absorbance of 2.343 at a peak (wavelength) of 230 nm, confirmed the synthesis of manganese nanoparticles (MnNPs). From the analysis, it can be concluded that Stubborn grass (*Eleusine indica)* has high sorption ability and manganese nanoparticles were successfully produced.

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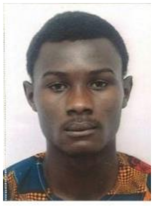

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Linda Dzetugbi Ayedzi is a graduate metallurgist from the prestigious University of Mines and Technology located in Ghana. She has been learning and practicing metallurgy close to a decade now and has had the opportunity to work in a couple of companies. Her zeal to learn and dedicated persona gained her a graduate training program and subsequent employment in the Ghana Manganese Company Limited (GMC). During her stay in GMC she gained an interest in manganese nanoparticles and this inspired her current paper. Currently, Linda is developing and building upon her research skills with the help of pioneers in the minerals industry.

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