UNIVERSITY OF NAIROBI

GREEN ROUTE SYNTHESIS OF ZINC OXIDE NANOPARTICLES USING *SPATHODEA CAMPANULATA* EXTRACT, CHARACTERIZATION AND APPLICATION IN ETHANOL SENSING

BY

PHILLIS EMELDA OCHIENG

I56/81175/2012

A thesis Submitted in Partial Fulfillment of the Requirements for the

Award of the Degree of Masters of Science (Chemistry) of University of Nairobi

2015

DECLARATION

I declare that this thesis is my original work except where due references are made and acknowledged in accordance with the University of Nairobi's requirements. It has not been submitted partially or wholly elsewhere for examination, award of a degree or publication.

Signature……Date……

Phillis Emelda Ochieng

I56/81175/2012

Department of Chemistry

University of Nairobi

This thesis has been submitted for examination with our approval as research supervisors.

Signature……..Date……..

Prof. Geoffrey Kamau

Department of Chemistry

University of Nairobi

Signature……Date……

Dr. Immaculate Michira

Department of Chemistry

University of Nairobi

DEDICATION

This work is dedicated to my late father Mr. Maurice Ochieng, my mother Karen Akeyo and my lovely daughters Kristy and Karen.

ACKNOWLEDGEMENTS

I would like to thank the Almighty God for His grace and mercy that saw me through this work. My deepest gratitude goes to my supervisors: Professor Geoffrey Kamau, the University of Nairobi; and Dr. Immaculate Michira, the University of Nairobi for introducing me to this innovative topic, for the ideas, talks and moral support throughout this research period.

I extend special thanks to Professor Emmanuel Iwuoha, Dr. Masikini Milua and the scholars at the Sensor lab, university of the Western Cape. Without their help I could not complete my work successfully.

I appreciate the support of my colleagues at Nairobi University, Departments of Chemistry and Physics. Special thanks go to Scolastica Manyim, Veronica Masila, Jane Macharia and the nanotechnology research scholars: Moses Oyagi, John Ondieki, Joshua Sila and Caroline Ouma.

I am grateful to my late father for being so proud of me; “you are still my pillar”. I thank my mother for the love that has given me confidence and strength through thick and thin. I am grateful to my daughters Kristy and Karen for their beautiful and inspiring smiles.

Katholischer Akademischer Auslander-Dienst (KAAD), Southern and Eastern Africa Network of Analytical Chemists (SEANAC) and Sensor Laboratory, University of Western Cape are hereby acknowledged for their financial support.

ABSTRACT

Nanotechnology is currently occupying the minds of many researchers and receiving tremendous focus. This is due to the fact that nanoparticles have most of their constituting atoms on their surfaces in addition to being similar to biomolecules. These two properties make nanoparticles have unique and noble properties compared to their bulk counterparts. Nanoparticles thus have found immense applications in sensors, medicine, cosmetics, optoelectronics, environmental protection, information storage and in catalysis.

Chemical and physical methods used for synthesis of nanoparticles suffer from many drawbacks like the use of toxic chemicals, high energy consumption and expensive equipment. Biological methods specifically the use of plants is currently under exploitation due to the fact that they are a cost effective and environmentally friendly way of synthesizing nanoparticles. In the present study, zinc oxide nanoparticles (ZnO NPs) were successfully synthesized using zinc nitrate and aqueous bio components of leave extract of *Spathodea campanulata* as the reducing as well as stabilizing agent. The medicinal value of *Spathodea campanulata* was an important factor in its selection for the biosynthesis of zinc oxide nanoparticles (ZnO NPs).

The biosynthesized nanoparticles were characterized using scanning electron microscopy (SEM), transmission electron microscopy (TEM), UV-Visible spectroscopy, attenuated total reflection Fourier transform infrared (ATR-FTIR), energy dispersive X-ray spectroscopy (EDX) and X-ray diffraction (XRD). Formation of nanoparticles was monitored using colour changes (eyes) and UV-Visible spectroscopy, whereby absorption in the range of 320-330nm was observed. From the transmission electron microscopy (TEM) images, the fashioned ZnO Nano-crystallites were of uniform morphology and size range of 20-50nm. XRD characterization revealed the face-

centered cubic of highly crystalline nanoparticles. All the XRD peaks were indexed to diffraction data (111), (200), (202), (311), (222), (400), (331), (420) and (422). SEM images at different resolutions of 1µm, 10µm and 200nm revealed spherically shaped and smooth surfaced nanoparticles arranged on top of one another. The EDX gave strong signals for zinc and oxygen at energies 137.6888 eV and 118.0190 eV respectively, indicating the occurrence of the nanoparticles in their oxide form rather than the pure zinc form. From the FTIR spectra of the zinc oxide nanoparticles, the characteristic absorption peak of Zn-O bond was observed at 848cm^{-1}. The spectra of the *Spathodea campanulata* extract gave an O-H stretch of polyphenols at 3222cm^{-1}, nitrile group from proteins at 2339cm^{-1} and double substituted aromatic bending at 682cm^{-1}.

Cyclic voltammetry was used to study the electrochemical properties of the ZnO nanoparticles based ethanol sensor. The surface area of glassy carbon electrode (GCE) was modified using ZnO nanoparticles and this enhanced the current response for the electrochemical nanosensor with a detection limit of 90ppm being achieved. The study showed that the ZnO nanoparticles have potential applications in new generation ethanol sensors.