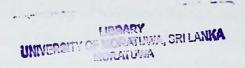
# PREPARATION AND CHARACTERIZATION OF NUTRIENT RICH NANOPARTICLES / COMPOSITES FOR AGRICULTURAL APPLICATIONS



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Thesis submitted in partial fulfillment of the requirements for the degree of Master of Philosophy



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July 2011

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### Declaration

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# Acknowledgement

I acknowledge with gratitude the Sri Lanka Institute of Nanotechnology (SLINTEC) for giving me the opportunity to conduct this project with full financial support while providing all the other necessary facilities.

I am grateful to Prof. V. Karunaratne, Dr. N. S. Kottegoda and Dr. F. M. Ismail, my supervisors who very generously spent their precious time to provide necessary guidance and assistance to carry out this task.

I also extend my gratitude and thank to Dr. A. D. U. S. Amarasinghe, Head of the Department, Chemical and Process Engineering, University of Moratuwa for providing me with all necessary assistance in carrying out this project.

Further I wish to sincerely thank to Prof. Ajith de Alwis, Dr. Shantha Amarasinghe and Dr. Lilantha Samaranayake, who helped me in numerous ways to complete my project successfully.

I am also thankful to my colleagues at SLINTEC for encouragement and assistance extended to me.

### Abstract

The work describes a novel strategy for controlled and sustained release of plant nutrients nitrogen (N), phosphorous (P) and potassium (K) into soil. In the study two nano systems, (a) inorganic inner nano-core consisting of macronutrient nanoparticles (b) a natural cellulose based outer core containing micro / nano porous cavities were used in order to obtain slow and sustained release of nutrients. Hydroxyapatite (HA) nanoparticles were synthesized, surface modified using urea and characterized using PXRD, SEM / EDX, AFM, FTIR and TGA / DTA. Urea modified HA nanoparticles dispersion and saturated potassium chloride solution were separately pressurized into the cavities present in Gliricidia sepium, a soft wood stem, under a pressure of 9 bar. N, P and K release behavior of the nanofertilizer composition was studied using soil from three elevations in Sri Lanka (pH 4.2, 5.2 and 7) and the release properties were compared with that of a commercial fertilizer composition. The release properties of the nanofertilizer show a slow and sustained release. In general, at all pH values, even on day 32, the remaining N to be released in the nanofertilizer was about 20% and there was no more N to be released in the commercial fertilizer. A similar trend shows for K release and at all pH values the remaining K to be released in nanofertilizer after 40 days was about 15% while there was no more K to be released in the commercial fertilizer. The solubility of P of in the nanofertilizer system was higher than the P release of the commercial fertilizer.

A model was developed for the solubility of bulk HA / HA nanoparticles. The solubility of HA in terms of soluble phosphate (PO<sub>4</sub><sup>3</sup>-) can be expressed by an equation,

$$[PO_4^{3-}]_{tota!} = \left(\frac{K_{Sp}}{K_W}\right)^{\frac{1}{8}} \times \frac{\left[\left(\alpha_{H^+}\right)^{\frac{1}{3}} + \left(\alpha_{H^+}\right)^{\frac{4}{3}} + \left(\alpha_{H^+}\right)^{\frac{7}{3}} + \left(\alpha_{H^+}\right)^{\frac{10}{3}}\right]^{\frac{3}{8}}}{\left[\frac{3}{5} \times e^{\left[-\frac{1}{2.303}\left|Z_{Ca^{2+}}\right|^2 \times 0.509 \times \sqrt{I}\right]\right]^{\frac{5}{8}}}}$$

From pH 3 to 4 and pH 4.5 to 6 the decrement of log value of total soluble phosphate concentration per unit pH is 11.8 and 3.03, respectively, when the ionic strength of the soil solution is between 12 to 110 mol kg<sup>-1</sup> according to the Ostwald and Freundlich equation, the solubility of phosphate can be increased by reducing the size of HA, that is, by using HA nanoparticles.

Key words: slow release, macronutrients, fertilizer, nanoparticles, wood

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# LIST OF ABBREVIATIONS

N/ha

N ha<sup>-1</sup> day<sup>-1</sup>

Abbreviation	Description
Å	Angstrom
AFM	Atomic Force Microscope
ATR	Attenuated Total Reflectance
AES	Auger Electron Spectroscopy
CRF	Controlled Release Fertilizer
DHA	Defective Hydroxyapatite
DNA	Deoxyribonucleic Acid
\$	Dollar
EBSD	Electron Back Scatter Diffraction
EDS	Electronic Data Systems
EDX	Energy Dispersive X-ray analysis
EDS	Energy Dispersive X-ray Spectroscopy
FTIR	Fourier Transform Infrared Spectroscopy
FWHM	Full Width at Half Maximum
g	gram
g kg <sup>-l</sup>	gram per kilogram
НР	Hewlett-Packard
НА	Hydroxy Apatite
IBM	International Business Machines
ICDD	International Centre for Diffraction Data
kg	kilogram
KHz	Kilo Hertz
kV	Kilo Volts
mg kg <sup>-l</sup>	milligram per kilogram
mg l <sup>-1</sup>	milligram per liter

Nitrogen per hectare per day

Nitrogen per hectare

NBP Nanotechnology Based Pesticides

NUE Nitrogen Utilization Efficiency

Pa Pascal

PSCU Polymer coated Sulphur Coated Urea

PDF Portable Document Format

PXRD Powder X-ray Diffraction

SEM Scanning Electron Microscope

STM Scanning Tunneling Microscope

SSNM Site Specific Nutrient Management

SRF Slow Release Fertilizer

SLS Sri Lanka Standards

SCU Sulphur Coated Urea

TA Thermal Analysis

TGA Thermo Gravimetric Analysis

TCP Tri Calcium Phosphate

US United State

WDS Wavelength-Dispersive X-ray Spectroscopy

XPS X ray Photoelectron Spectroscopy

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