DEVELOPMENT AND EVALUATION OF POLYSACCHARIDE BASED SUPER ABSORBENT POLYMERS (SAPs) BY IRRADIATION FOR APPLICATIONS OF AGRICULTURE

By

THEWARATHANTHRIGE NILANTHI FERNANDO

A Thesis is Submitted in Fulfillment of the Requirement for the Degree of Doctor of Philosophy

Department of Agricultural and Plantation Engineering
Faculty of Engineering Technology
The Open University of Sri Lanka
2017

Internal Supervisors

Senior Professor S. A Ariyadurai
Senior Professor in Department of Textile and Apparel Technology,
Faculty of Engineering Technology, The Open University of Sri Lanka.

Dr. (Mrs) A.G.B. Aruggoda
Senior Lecturer, Department of Agricultural and Plantation Engineering,
Faculty of Engineering Technology, The Open University of Sri Lanka

External Supervisors

Ms. Champa Disanayaka
Deputy Director, Food and Agriculture Section,
Sri Lanka Atomic Energy Board, Colombo.

Ms. Samantha Kulathunge
Former Director, Sri Lanka Gamma Centre, Sri Lanka Atomic Energy Board, Colombo.

DECLARATION

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any University or higher educational institution in Sri Lanka or abroad and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Author's name: Ms. T. Nilanthi Fernando Date: 27.12.2017

Signature : .....

This is to certify that this dissertation is based on the work carried by Ms. T. Nilanthi Fernando under our supervision. The dissertation has been prepared according to the format stipulated and is of acceptable standard.

Certified by:

Supervisor 1. Name Prof. S. A. Ariaduraj Date 28/12/2017

Signature .....

Supervisor 2. Name Dr. A. G. B. Anggoda Date 2017/12/28.

Signature .....

Supervisor 3. Name Champa Dissanayake Date 27.12.2017

Signature .....

Supervisor 4. Name Samantha Kulatunge Date 27.12.2017

Signature .....

ABSRACT

Super Absorbent Polymers (SAPs) are structurally cross-linked, highly swollen and hydrophilic polymer networks capable of absorbing a large amount of water or aqueous saline solutions, practically 10 to 1000 times of their original weight or volume. The slow release of water to the growth media could allow retention of moisture, reducing irrigation frequency hence help save farmers money spent on water. One method of manufacture of biodegradable SAPs is grafting copolymerization of suitable vinyl monomer(s) on polysaccharide in the presence of a cross-linker. Chitin, cellulose, starch, and natural gums (such as xanthan, guar and alginates) are some of the most important polysaccharides. A SAP by the name of "GAM-sorb" using cassava starch and acrylic acid graft under gamma irradiation has been produced in Vietnam. However, in Sri Lanka use of cassava starch as the main input material for producing SAP would not be practicable due to its high cost. The present study focused on evaluating the performance of the imported SAP, named GAM-sorb, on the feasibility of using it in Sri Lanka. Further, the study involved development of cross-linked Cellulose and acrylic acid grafted (cross-linked Cellulose-g-PAA(Na)) SAPs in Sri Lanka under irradiation for various practices in agriculture and the developed SAPs were named as SLSAPs. Preliminary development of SLSAP was done by using combination of conventional and microwave heating. Afterward, six cross-linked Cellulose-g-PAA(Na) SLSAPs were prepared by graft polymerization of neutralized Acrylic Acid (AA) on to three cellulose samples separately, which were extracted from bagasse using alkaline, alkaline hydrogen peroxide and microwave assisted alkaline pretreatments in the presence of N,N-methylenebisacrylamide (MBA) as a cross-linker using microwave irradiation and gamma irradiation. Additionally, cross-linked PAA(Na) SAP was

prepared without applying cellulose to compare the characteristics with developed cross-linked Cellulose-g-PAA(Na) SLSAPs under microwave and gamma irradiation. Characteristics of grafting, morphological and soil degradation of developed SAPs were identified by using Fourier Transform Infra-Red Spectrometry, Scanning Electronic Microscopy and soil burial method, respectively. Additionally, Thermo gravimetric analysis was done to identify thermal stability of developed SAPs and water absorbency were measured in distilled water and other prepared fertilizer solutions. Water release pattern in incorporated soil and room environment were evaluated. Different agricultural practices such as characteristics of seed germination in swollen SLSAPs added media, survival of transplanted seedlings in SLSAP incorporated coir dust medium, development of SLSAP added coir dust pellet for survival of seedlings, cultivation of crops in SLSAPs incorporated prepared layer wise medium and survival of cut *Chrysanthemum instagram* flowers in SLSAPs added media were evaluated. The results of experiments indicate that use of "GAM-sorb" in growth media certainly reduces the frequency of watering. Further, the developed SLSAPs had swelling ratios of 236-325 in distilled water. Compared to cross-linked PAA(Na), cross-linked Cellulose-g-PAA(Na) SAPs had highly porous structure, favourable degradability in sandy loam soil and thermal stability between approximately 200^{o}C- 275^{o}C. The results also indicate that developed cross-linked Cellulose-g-PAA(Na) SLSAPs are useful for seed germination, survival of transplanted seedlings, survival of cut flowers and for cultivation of crops under limited supply of water.

ACKNOWLEDGEMENT

I extend special thanks to my internal supervisors Professor S.A. Ariadurai and Dr. (Mrs.) A.G.B. Aruggoda for their interest shown and for continuous encouragement, guidance and advice given throughout the course of study devoting time for correcting manuscripts of this project. I wish to express my sincere gratitude to my external supervisors Ms. S. Kulathunge, former Director, Sri Lanka Gamma Centre of Atomic Energy Board (AEB) of Sri Lanka and Ms. C. K Disanayaka, Deputy Director, AEB for accepting me as a team member of the RAS 1014 project. I thank Ms. A. Ratnayake, Director, Sri Lanka Gamma Centre, AEB and other members of RAS 1014 project for assisting me to make this project a success. Professor W.A. Wimalaweera and Eng. Mr. P. D. Sarathchandra for their invaluable support given me to initiate the research and for help given to register for the PhD degree at the OUSL. My special thanks go to Dr K.A.C. Udayakumara, the Dean, Faculty of Engineering Technology, OUSL for his utmost support given whenever needed. I aknolwledge assistance given by Dr. Prasad Senadeera, Senior lecturer at the Faculty of Natural Secience, OUSL in providing research instruments, support given by Mr. Hemaka De Mel, Manager, Human Tissue Bank of Sri Lanka and his staff for allowing me the use of facility for irradiation. I also thank Prof. R.G.N.De.S. Munasinghe, Dr. S.U Adikari and technical officer Mr. M.A.P.C.Gunawardena in the Dept. of Material's Science and Engineering, Faculty of Engineering, University of Moratuwa, Sri Lanka for allowing me the use of FTIR and TGA analysis facilities. Technical officer Mr. K.C.K. Deraniyagala Dept. of Mechanical Engineering, OUSL for valuable technical support. Special thanks to Mr. B. Gunaratne, Mr. A.M.S.N.N Adikari, Mr.D.J.H N.J Kumara for making this project a success.