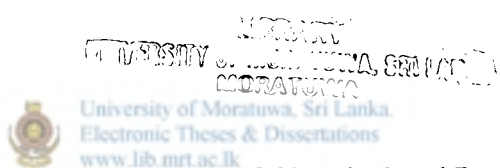


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PREPARATION AND CHARACTERIZATION OF ENVIRONMENTALLY FRIENDLY POLYMERIC BLENDS USING SYNTHETIC AND NATURAL POLYMERS

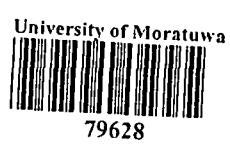
by

G. M. Gayani Dhammika Dias



This Thesis was submitted to Department of Chemical and Process Engineering of the University of Moratuwa in partial fulfillment of the requirement for the Degree of Master of Science in Polymer Technology

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Department of Chemical and Process Engineering
University of Moratuwa
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DECLARATION

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(Dr. B A J K Premachandra)

ABSTRACT

This thesis is consisted of four chapters. Chapter one contains an introductory part including scope and the objectives of the research. Since the present research is divided in to three major parts, chapter two, three and four is arranged accordingly. Each chapter includes an introduction discussing the relevant literature, the experimental work, results and discussions and finally, the conclusions drawn. The contents of this thesis can be best summarized as follows.

Mechanical properties and biodegradability of composites of LDPE with tapioca starch

A series of LDPE/starch composites containing different amounts of starch (as wt %) were prepared using tapioca starch in its native granular form. Mixing was done by dissolving LDPE in cyclohexane pre-heated to its boiling point and subsequently dispersing starch granules by using Silverson emulsifier. The composites were studied by using Fourier Transform Infra-red spectroscopy (FTIR). The failure modes, mechanical properties, water absorption, biodegradation and the biodegradation after thermal incubation were investigated as a function of the composition of the composite. It was found that the incorporation of starch into LDPE matrix has reduced the ductility of the composite. The mechanical properties of the composites, especially the tensile strength and elongation at break were significantly low compared to those of neat LDPE. A significant improvement in modulus was shown by the composites. It was found that the mechanical properties were depended on the composition of the composite.

The extent of the biodegradability, after exposure to α -amylase enzyme solution, was assessed by weight loss measurements and loss of mechanical properties such as tensile strength and percentage elongation. It was found that these composites are biodegradable and the rate of biodegradation increases with increasing starch content. The extent of biodegradation after thermal incubation was assessed by the loss of tensile strength measurements of the composites after incubation of the samples in an

air circulation oven at 70 °C and subsequently exposing to α -amylase enzyme solution. It was found that the degradability of the samples was not significantly affected by the thermal incubation.

Preparation and characterization of long chain fatty acid esters of tapioca starch


A series of starch esters with different degree of substitution (DS) were prepared and studied. The esters were prepared by acylation of tapioca starch with appropriate acid chlorides such as stearoyl and oleoyl chlorides. Fourier transform infrared (FTIR) spectroscopy confirmed the formation of the starch esters and their DS. As a measurement of the DS of an ester the peak height ratio responsible for O-H bond stretching to C=O bond stretching of the esters were considered. The DS of starch stearates were 5.3, 4.5, 2.6, 2.0 and 1.60. The DS of starch oleates were 3.55, 2.0, 1.90 and 1.21. With increasing DS the color intensities of the esters were improved. Melting temperatures of the esters were determined by using Differential thermal analyzer. The thermo-oxidation degradation of tapioca starch and starch esters, were assessed by using Fourier Transform Infra-red (FTIR) spectroscopy, after the incubation of the samples in an air circulation oven at 70 °C. The presence of thermo-oxidative degradation was shown in both types of the starch esters. Starch has not shown thermo-oxidative degradation.

Mechanical properties and biodegradability of composites of LDPE with fatty acid esters of tapioca starch

A series of Low Density Polyethylene (LDPE) composites containing different amounts of fatty esters of starch were prepared. Mixing was done by dissolving LDPE, in cyclohexane pre-heated to its boiling temperature, and subsequently, mixing starch esters using Siverson Emulsifier. Two different types of starch esters, starch stearate and oleate with different (DS) were utilized in the preparation of these LDPE composites. Polarized light micrographs were used to assess the miscibility of LDPE with starch esters.

The miscibility of the components was found to be improved with increasing DS of the ester. Water absorption, mechanical properties, biodegradation and biodegradation after thermal incubation were investigated as a function of the composition of the composite. Comparing with the LDPE/starch composites a significant reduction in the water absorption was resulted in the LDPE/starch ester composites. It was found that as the amount of esters increases in the composite, the tensile strength and especially the elongation at break decrease non-linearly. The LDPE/starch ester composites containing starch esters of high DS have shown improved tensile properties than those of LDPE/starch composites. As expected, the fatty ester chains in the starch ester molecules have not shown the plasticizing effect in the composite. The percentage elongation properties were significantly reduced with the introduction of the esters into LDPE.

The extent of the biodegradability of the composites after exposure to α -amylase and lipase enzyme solutions was assessed by weight loss and mechanical properties measurements. The rate of biodegradation of LDPE/starch ester composites was relatively low compared to that of LDPE/starch composites. The rate of biodegradation of these LDPE/starch ester composites further decreases with increasing DS of the ester in the composite. The extent of the biodegradation of the composites after incubation of the samples at air circulation oven at 70 °C and subsequently immersing in the enzymatic solutions was assessed by the tensile strength measurements. It was found that the degradability of the ester composites was significantly high and the degradation rate increases with the increasing DS of the ester. Highest rate of degradation was observed in the LDPE/starch ester composite containing starch oleate of the highest DS.

To my parents,
the first teachers in my life,
To my husband,
for his motivation towards the success in my life,
To my son,
whose smile gave me a new hope to my life,
I dedicated this thesis,
with joy and happiness,
 to owe my gratitude to them.



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Without them, their love and blessing, I may not finish this thesis today.

ACKNOWLEDGEMENTS

I wish to express my deepest gratitude to my supervisor, to whom I am deeply indebted, Dr Jagath K Premachandra, Department of Chemical and Process Engineering, University of Moratuwa. His interest in this study, advice and criticism have motivated me immensely and guided me on the pathway to the successful completion of this work. I would like to express my deep gratitude to Dr. Shantha Walpalage, Head of the Polymer Division, Department of Chemical and Process Engineering, University of Moratuwa for the helpful ideas, special advices and motivation provided which always strengthened me to successfully complete this work.

I would like to acknowledge Dr. Gamini Senevirathna, Deputy Director General, Rubber research Institute, Mrs. Dilhara Edirisinghe, for granting permission to carryout practical in their institute premises. I render my heartiest gratitude and special thank to Mr. Chandralal Perera and Mrs. Indra Denawake, for their immense corporation and assistance towards my research and further, acknowledge all staff members and technical officers of Rubber Research Institute, Ratmalana, for their kind corporation.

My deep gratitude goes to Dr. N Munasinghe, Head of the Materials Engineering Department, University of Moratuwa, for his kind assistance in granting me to use laboratory equipments in his department. I further, extend my gratitude and special thank to the academic staff member Mr. V S C Weragoda and the senior staff technical officer, Mr. Sarath Chandrapala for their immense corporation and assistance towards my research work.

I further, acknowledge Dr. Sudantha Liyanage, Head of the Polymer Division, Department of Chemistry, University of Sri Jayawardenapura and Prof. Bamunuarachchi, Head of the Department of Food Technology, University of Sri Jayawardenapura for granting me permission to use laboratory facilities in their

departments. I acknowledge with special thanks to the Technical officer Mr. Sagara Dias, for his immense assistance given to me.

I further extend my deep gratitude to Dr. (Mrs.) Padma Amarasinghe, Head of the Department of Chemical and Process Engineering, University of Moratuwa, all academic staff and the laboratory staff of the department for their support in numerous ways, for which I will always be thankful. I will indebted to Asian Development Bank for granting financial assistance for the course of study.

Finally, I owe many thanks and heartiest gratitude to my parents, especially, to my patient mother, and to my husband who capably typed and retyped many parts of this text and for their immense corporation in numerous ways, which motivated me to successfully complete this work.



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LIST OF ABBREVIATIONS

CaCO ₃	- Calcium Carbonate
DS	- Degree of Substitution
EAA	- Ethylene Acrylic Acid
EVOH	- Ethylene Vinyl Alcohol
FTIR	- Fourier Transform Infra- Red
h	- Hours
HCl	- Hydro Chloric Acid
HDPE	- High Density Polyethylene
LDPE/PE	- Low Density Polyethylene
MPa	- Mega Pascal
PCL	- Poly Caprolactone
PET	- Polyethylene Terephthalate
PES	- Low Density Polyethylene/ Starch Composite
PESO	- LDPE/ Starch Oleate Composite Lanka
PESS	- LDPE/ Starch Stearate Composite
PG	- Poly Glycolide
PHB	- Poly Beta hydroxy Butyrate
PHV	- Poly Hydroxy Valarate
PL	- Poly Lactic
rpm	- Rounds per minutes
TiO ₂	- Titanium dioxide
T _m	- Melting temperature
T _g	- Glass transition temperature
wt %	- Weight percentage