PREPARATION, CHARACTERIZATION, PROPERTIES AND DEGRADATION BEHAVIOUR OF PEANUT SHELL POWDER/ RECYCLED POLYPROPYLENE COMPOSITES

by

NOR FASIHAH BINTI ZAABA

Thesis submitted in fulfillment of the

requirements for the degree of

Doctor of Philosophy

January 2017

ACKNOWLEDGEMENTS

First and foremost, my utmost gratitude and praise is to Allah, the Most Merciful and Most Compassionate for His blessings, that I was able to complete this research work. I feel so blessed for the given opportunity and granting the capability to proceed successfully. Completing my PhD degree is probably the most challenging activity of my 29 years of life. The best and worst moments of my doctoral journey have been shared with many people. I would like to express my sincere gratitude to all of them.

To my PhD supervisor, Prof. Dr. Hanafi Bin Ismail, I am extremely grateful for his valuable guidance, scholarly inputs and consistent encouragement I received throughout the research work. It is a great opportunity to do my doctoral program under his supervision and to learn from his research expertise. I also would like to express my gratitude to the one who always has confidence in me, Prof. Ir. Dr. Mariatti Bt Jaafar. She was among those who kept me going at the beginning, who was the source of inspiration since the early days, and who taught me many things, including academic and career planning, personal related matters as well as life and spiritual conduct.

Most of the results described in this thesis would not have been obtained without a close collaboration with few laboratories. I owe a great deal of appreciation and gratitude to Mr. Shahril Amir bin Saleh and Mr. Mohd Suharuddin Bin Sulong (Rubber Lab), Mr. Mohammad Bin Hassan (Plastic Lab), Mr. Mohd Faizal Bin Mohd Kassim (Latex Lab), Mr. Abdul Rashid Bin Selamat and Mr. Muhammad Khairi Bin Khalid (SEM Lab), Mr. Norshahrizol Bin Nordin (Workshop) as well as Mr. Mokhtar Bin Mohamad (Metallographic Lab) for their help and support during my experimentation in those laboratories. Besides, I would like to thank administrative and technical staff members of the SMMRE, USM who has been kind enough to advise and help in their

respective roles. I am indebted to my research group colleagues for providing a stimulating and fun filled environment. Many thanks go in particular to Shazlin Bt Shaari, Norshahida Bt Sarifuddin , Teo Pao Ter, Ooi, Mathialagan Muniayadi, Pang Ai Ling, Dalina Bt Samsudin, Faiezah Bt Hashim, Siti Zuliana Bt Salleh, Komethi Muniandy, Noranizah Bt Mohamad Aini for their personal and scholarly interaction. Words are short to express my deep sense of gratitude towards my following friends. Many thanks go to fellow friends who give their ears to listen to, their shoulders to cry on, their hearts to care specially Nursyazalina Bt Mustafa, Nurayuni Bt Syukor, Noor Izzati Bt Muhd Nasir and Muhammad Ariff Bin Abdul Razak for this twenty years' friendship and for their constant support in every way.

A gratefully wonderful thanks belong to my little caliph, Zayyan Zill Qayyim Bin Zakir Irman. Thank you for being my new inspiration and motivation in performing my best in every single thing I do.

My special words of heartiest appreciation also dedicated to my beloved husband, Zakir Irman Bin Sozaini, my late dearest father, Allahyarham Zaaba Bin Osman, my lovely mother, Khadijah Bt Mohamed, my father and mother-in-law, Sozaini Bin Ali and Jarinah Bt Sultan for their non-stop encouragement and support to me through laugh and tears. I will never forget what we've gone through in some phase of life emotionally and financially, and that made me really appreciate this pathway. Besides, my special thanks also dedicated to my brother Ahmad Fairus Bin Zaaba , my sisters-in-law Rogayah Bt Ramli and Zarini Izzati Bt Sozaini for their care and love. Finally, I am also grateful to the financial support received through MyBrain15 from the Ministry of Education of Malaysia and Cluster for Polymer Composites (CPC) and Solid Waste Management (SWM USM) Grant.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
CEN	European Committee for Standardization
CI	Carbonyl Index
DSC	Differential Scanning Calorimetry
DTG	Derivative Thermogravimeric
EB	Electron Beam
FESEM	Field Emission Scanning Electron Microscopy
FTIR	Fourier Transform Infra Red
HDPE	High Density Polyethylene
LDPE	Low Density Polyethylene
LLDPE	Linear Low Density Polyethylene
MSW	Municipal Solid Waste
NaOH	Sodium Hydroxide
PE	Polyethylene
PEAA	Polyethylene-co-Acrylic Acid
PET	Polyethylene Terephthalate
PLA	Poly (lactic acid)
PMMA	Poly(methyl methacrylate)
PP	Polypropylene
PS	Polystyrene
PSP	Peanut Shell Powder
PVC	Poly(vinyl chloride)
PVOH	Poly(vinyl alcohol)

RPP	Recycled Polypropylene
SEM	Scanning Electron Microscopy
TG	Thermogravimeric
TGA	Thermogravimetric Analysis
UV	Ultraviolet
WA	Water Absorption
XRD	X-ray Diffraction

LIST OF SYMBOLS

%	Percentage
ΔH_f	Heat of fusion
ΔH_m	Melt enthalpy
°C	Degree Celsius
°C/min	Degree Celsius per minute
cm	Centimetre
g	Gram
g/cm^3	Gram per centimeter cubic
GPa	GigaPascal
m^2/g	Meter square per gram
min	Minute
mm	Millimeter
mm/min	Millimeter per minute
MPa	MegaPascal
mW	miliWatt
nm	Nanometer
phr	Parts per hundred
rpm	Revolutions per minute
s	Second
T	Temperature
T_c	Crystallization temperature
T_d	Decomposition temperature
T_g	Glass transition temperature

T_m	Melting temperature
w/w	Weight to weight ratio
wt.%	Weight percent
X_c	Degree of crystallinity