

**CHARACTERIZATION AND FLAMMABILITY OF ETHYLENE VINYL ACETATE
(EVA)/ZEOLITE COMPOSITES**

by

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TABLE OF CONTENTS

Table of Contents	iii
List of Tables	viii
List of Figures	x
List of Abbreviations	xvii
List of Symbols	xviii
Abstrak	xix
Abstract	xxi
CHAPTER 1- INTRODUCTION	
1.0 Introduction	1
1.1 Background of the Present Research	2
1.2 Problem Statements	4
1.3 Objectives of Study	6
1.4 Organization of the Thesis	6
CHAPTER 2- LITERATURE REVIEW	
2.0 Literature review	8
2.1 Composites	8
2.2 Particulate filled composites	9
2.3 Matrix	11
2.3.1 Ethylene vinyl acetate (EVA)	12
2.4 Interphase or interface	14
2.4.1 Silane coupling agents	17
2.4.2 Organic amines	19
	23

2.4.3	Polymer modifications	
2.5	Filler	26
2.5.1	Zeolite	27
2.5.2	Zeolite filled polymer composites	30
2.6	Factors affecting the properties of particulate filled composites	32
2.6.1	Geometry of fillers	32
2.6.2	Nature of polymer matrix	33
2.6.3	Filler-matrix interfacial adhesion	34
2.7	Applications of particulate filled composites	35
2.8	Characterization and properties of particulate filled composites	37
2.8.1	Mechanical properties	37
2.8.2	Thermal properties	38
2.8.3	Flammability	40

CHAPTER 3- MATERIALS AND METHODOLOGY

3.1	Raw materials	45
3.1.1	Ethylene vinyl acetate (EVA)	45
3.1.2	Zeolite	46
3.1.3	Dicumyl peroxide (DCP)	47
3.1.4	Octadecylamine	48
3.1.5	3-aminopropyltriethoxysilane (AMPTES)	48
3.1.6	Ammonium polyphosphate (APP)	49
3.1.7	Pentaerythritol (PER)	50

3.2	Size reduction of zeolite	50
3.3	Surface modifications	52
	3.3.1 Crosslinking of EVA	52
	3.3.2 Cation exchange method	52
	3.3.3 Silane surface treatment	53
3.4	Preparation of composite sample	54
	3.4.1 Compounding	54
	3.4.2 Moulding and Preparation of Test Sample	56
3.5	Characterization	57
	3.5.1 Gel content measurement	57
	3.5.2 Tensile test	58
	3.5.3 Dynamic mechanical analysis (DMA)	59
	3.5.4 Thermogravimetric analysis (TGA)	59
	3.5.5 Differential scanning calorimetry (DSC)	60
	3.5.6 UL-94 test	61
	3.5.7 Limiting oxygen index (LOI) test	62
	3.5.8 Morphology study using Scanning Electron Microscope (SEM)	62
	3.5.9 Fourier Transform Infrared Radiation (FTIR)	63

CHAPTER 4- RESULTS AND DISCUSSION

4.1	Effect of zeolite loading on properties of EVA/zeolite composites	64
	4.1.1 Tensile properties	64
	4.1.2 Dynamic mechanical analysis (DMA)	69

4.1.3	Thermogravimetric analysis (TGA)	74
4.1.4	Differential scanning calorimetry (DSC) analysis	76
4.2	Effect of crosslinking on properties of EVA/zeolite composite	78
4.2.1	Tensile properties	78
4.2.2	Dynamic mechanical analysis (DMA)	83
4.2.3	Thermogravimetric analysis (TGA)	87
4.2.4	Differential scanning calorimetry (DSC) analysis	89
4.2.5	Fourier Transform Infrared Radiation (FTIR) analysis	91
4.2.6	Determination of gel content	93
4.3	Effect of cation exchange method on properties of EVA/zeolite composites	95
4.3.1	Tensile properties	95
4.3.2	Dynamic mechanical analysis (DMA)	99
4.3.3	Thermogravimetric analysis (TGA)	102
4.3.4	Differential scanning calorimetry (DSC) analysis	104
4.3.5	Fourier Transform Infrared Radiation (FTIR) analysis	106
4.4	Effect of silane modification on properties of EVA/zeolite composites	107
4.4.1	Tensile properties	107
4.4.2	Dynamic mechanical analysis (DMA)	112
4.4.3	Thermogravimetric analysis (TGA)	115
4.4.4	Differential scanning calorimetry (DSC) analysis	117
4.4.5	Fourier Transform Infrared Radiation (FTIR) analysis	119

4.5	Effect of intumescent flame retardant (IFR) on properties of EVA/zeolite composites	120
4.5.1	Tensile properties	120
4.5.2	Thermogravimetric analysis (TGA)	123
4.5.3	Differential scanning calorimetry (DSC) analysis	125
4.5.4	UL-94 analysis	127
4.5.5	Limiting oxygen index (LOI) analysis	129
4.5.6	Fourier Transform Infrared Radiation (FTIR) analysis	132
4.6	Scanning electron microscopy (SEM) analysis	133
4.6.1	Tensile fractured surface of composites	133
4.6.2	Char residues of composites	142
4.7	Study of different surface modification methods on mechanical properties of composites	144
	CHAPTER 5- CONCLUSIONS	148
	CHAPTER 6- REFERENCES	150

LIST OF TABLES

		Page
Table 3.1	Mechanical properties of EVA	45
Table 3.2	Properties of Mordenite	46
Table 3.3	Physical properties of DCP	47
Table 3.4	Physical properties of octadecylamine	48
Table 3.5	Physical properties of AMPTES	49
Table 3.6	Properties of APP	49
Table 3.7	Properties of PER	50
Table 3.8	The weight of DCP used in crosslinking of EVA	52
Table 3.9	The weight of AMPTES, ethanol and water used in surface treatment for different volume percentages of zeolite	53
Table 3.10	The amount of EVA and zeolite used in compounding process according to different zeolite volume percentages	55
Table 3.11	UL-94 flammability ratings summary	61
Table 4.1	TGA results of EVA matrix and its composites	76
Table 4.2	DSC results of EVA matrix and its composites	78
Table 4.3	TGA results of EVA/ zeolite/ DCP composites	89
Table 4.4	DSC results of EVA/zeolite/DCP composites	90
Table 4.5	TGA results of EVA/ Organozeolite composites	104
Table 4.6	DSC results of EVA/Organozeolite composites	105
Table 4.7	TGA results of EVA/zeolite/AMPTES composites	117

Table 4.8	DSC results of EVA/zeolite/AMPTES composites	119
Table 4.9	TGA results of EVA/zeolite/APP/PER composites	125
Table 4.10	DSC results of EVA/zeolite/APP/PER composites	127
Table 4.11	UL-94 testing results for EVA and its composites	129

LIST OF FIGURES

Page

Figure 2.1	Schematic view of the expansion of zeolite galleries resulting from ion exchange with a long chain organic amine	21
Figure 2.2	Structure of zeolites	27
Figure 2.3	Schematic representation of the pore structure of mordenite. Numbers 1 and 2 represent the two types of channels in the zeolite	30
Figure 2.4	Schematic representation of the pore structure of mordenite. Numbers 1 and 2 represent the two types of channels in the zeolite	30
Figure 3.1	Chemical structure of EVA	46
Figure 3.2	Ring mill machine	51
Figure 3.3(a)	Zeolite prior to grinding	51
Figure 3.3(b)	Zeolite after grinding	51
Figure 3.4	Thermo Haake Polydrive internal mixer machine	56
Figure 3.5	Gotech compression moulding machine	57
Figure 3.6	Instron tensile machine	58
Figure 4.1	Effect of zeolite loadings on the tensile strength of EVA/zeolite composites	64
Figure 4.2	The effect of zeolite volume percentages on the elongation at break of EVA/zeolite composites	67
Figure 4.3	The effect of zeolite volume percentages on the tensile	68

	modulus of composites	
Figure 4.4	Storage modulus of pure EVA and its composites at different zeolite loading versus temperature	70
Figure 4.5	Loss modulus of pure EVA and its composites at different zeolite loading versus temperature	72
Figure 4.6	Tan delta of pure EVA and its composites at different zeolite loading versus temperature	73
Figure 4.7	TGA curves of zeolite, EVA and its composites at various zeolite content	75
Figure 4.8	DTG thermograms of zeolite, EVA and its composites at various zeolite contents	76
Figure 4.9	The heating melt DSC curves of zeolite filled EVA composites with different zeolite contents	77
Figure 4.10	The effect of crosslinking by DCP on tensile strength of EVA/zeolite composites	79
Figure 4.11	The effect of crosslinking by DCP on elongation at break of EVA/zeolite composites	81
Figure 4.12	The effect of crosslinking by DCP on tensile modulus of EVA/zeolite composites.	82
Figure 4.13	The effect of crosslinking on storage modulus of EVA and EVA/zeolite composites as a function of temperature	84

Figure 4.14	The effect of crosslinking on loss modulus of EVA and EVA/zeolite composites as a function of temperature	85
Figure 4.15	The effect of crosslinking on tan delta of EVA and EVA/zeolite composites as a function of temperature	86
Figure 4.16	TGA curves of uncrosslinked and DCP crosslinked EVA/zeolite composites at various zeolite contents	88
Figure 4.17	DTG thermograms of uncrosslinked and DCP crosslinked EVA/zeolite composites at various zeolite contents	88
Figure 4.18	The heating melt DSC curves of DCP crosslinked EVA/zeolite composites with different zeolite contents	90
Figure 4.19	FTIR diagram of (a) pure EVA, (b) EVA/zeolite composites and (c) EVA/zeolite/DCP composites	92
Figure 4.20	FTIR diagram of (a) EVA/zeolite composites, (b) EVA/zeolite/DCP composites before Soxhlet extraction and (c) EVA/zeolite/DCP composites after Soxhlet extraction	93
Figure 4.21	Insoluble gel content of EVA/zeolite/DCP composites at different zeolite loading	95
Figure 4.22	The effect of cation exchange method on tensile strength of EVA/zeolite composites	96
Figure 4.23	The effect of cation exchange method on elongation at	98

	break of EVA/zeolite composites	
Figure 4.24	The effect of cation exchange method on tensile modulus of EVA/zeolite composites.	99
Figure 4.25	The effect of cation exchange method on storage modulus of EVA/zeolite composites as a function of temperature	100
Figure 4.26	The effect of cation exchange method on loss modulus of EVA/zeolite composites as a function of temperature	101
Figure 4.27	The effect of cation exchange method on tan delta of EVA/zeolite composites as a function of temperature	102
Figure 4.28	TGA curves of unmodified and organo-modified zeolite filled EVA composites at various zeolite contents	103
Figure 4.29	DTG thermograms of unmodified and organo-modified zeolite filled EVA composites at various zeolite contents	104
Figure 4.30	The heating melt DSC curves of organo-modified zeolite filled EVA composites with different zeolite contents	105
Figure 4.31	FTIR diagram of (a) zeolite (b) organo-modified zeolite (c) EVA/zeolite composites and (d) EVA/organo-modified zeolite composites	107
Figure 4.32	The effect of silane surface treatment on tensile strength of EVA/zeolite composites	109
Figure 4.33	The effect of silane surface treatment on elongation at	110

	break of EVA/zeolite composites	
Figure 4.34	The effect of silane surface treatment on tensile modulus of EVA/zeolite composites	111
Figure 4.35	The effect of silane treatment on storage modulus of EVA/zeolite composites as a function of temperature	113
Figure 4.36	The effect of silane treatment on loss modulus of EVA/zeolite composites as a function of temperature	114
Figure 4.37	The effect of silane treatment on tan delta of EVA/zeolite composites as a function of temperature	115
Figure 4.38	TGA curves of untreated and AMPTES treated zeolite filled EVA composites at various zeolite contents	116
Figure 4.39	DTG thermograms of untreated and AMPTES treated zeolite filled EVA composites at various zeolite contents	117
Figure 4.40	The heating melt DSC curves of AMPTES treated zeolite filled EVA composites with different zeolite content	118
Figure 4.41	FTIR diagram of (a) zeolite (b) AMPTES-treated zeolite (c) EVA/zeolite composites and (d) EVA/ AMPTES-treated zeolite composites	120
Figure 4.42	Tensile strength of EVA composites at 25 vol. % of zeolite content	121
Figure 4.43	Elongation at break of EVA composites at 25 vol. % of zeolite content	122

Figure 4.44	Tensile modulus of EVA composites at 25 vol. % of zeolite content	122
Figure 4.45	TGA thermograms of EVA and its composites having 25 vol. % of zeolite loading	124
Figure 4.46	DTG curves of EVA and its composites having 25 vol. % of zeolite loading	125
Figure 4.47	The heating melt DSC curves of studied composites having 25 vol. % of zeolite loading	127
Figure 4.48	LOI values of EVA and its composites	131
Figure 4.49	FTIR diagram of (a) EVA/zeolite composites (b) EVA/zeolite/APP1/PER composites (c) EVA/zeolite/APP2/PER composites	133
Figure 4.50	SEM micrograph of tensile fractured surface of 5% EVA/zeolite composites	137
Figure 4.51	SEM micrograph of tensile fractured surface of 25% EVA/zeolite composites	137
Figure 4.52	SEM micrograph of tensile fractured surface of 5% EVA/zeolite/DCP composites	138
Figure 4.53	SEM micrograph of tensile fractured surface of 25% EVA/zeolite/DCP composites	138
Figure 4.54	SEM micrograph of tensile fractured surface of 5% EVA/organo-zeolite composites	139

Figure 4.55	SEM micrograph of tensile fractured surface of 25% EVA/organo-zeolite composites	139
Figure 4.56	SEM micrograph of tensile fractured surface of 5% EVA/zeolite/AMPTES composites	140
Figure 4.57	SEM micrograph of tensile fractured surface of 25% EVA/zeolite/AMPTES composites	140
Figure 4.58	SEM micrograph of tensile fractured surface of 25% EVA/zeolite/APP1/PER composites	141
Figure 4.59	SEM micrograph of tensile fractured surface of 25% EVA/zeolite/APP2/PER composites	141
Figure 4.60	SEM micrograph of surface char residue of EVA/zeolite composites	143
Figure 4.61	SEM micrograph of surface char residue of EVA/zeolite/APP1/PER composites	143
Figure 4.62	SEM micrograph of surface char residue of EVA/zeolite/APP2/PER composites	144
Figure 4.63	Effect of different surface modification methods on tensile strength of EVA/zeolite composites	146
Figure 4.64	Effect of different surface modification methods on elongation at break of EVA/zeolite composites	146
Figure 4.65	Effect of different surface modification methods on tensile modulus of EVA/zeolite composites	147

LIST OF ABBREVIATIONS

EVA	Ethylene vinyl acetate
DMA	Dynamic mechanical analysis
SEM	Scanning electron microscopy
DCP	Dicumyl peroxide
AMPTES	3-aminopropyltriethoxysilane
FTIR	Fourier transform infra red
TGA	Thermogravimetric analysis
DSC	Differential scanning calorimetry
APP	Ammonium polyphosphate
PER	Pentaerythritol
LOI	Limiting oxygen index
UL-94-V	Vertical burning testing
IFR	Intumescent flame retardant
GC	Gel content
MPa	Mega pascal

Kg	Kilo gram
T_g	Glass transition temperature
DTG	Differential thermogravimetry

LIST OF SYMBOLS

%	Percentage
$^{\circ}\text{C}$	Degree celsius
ΔH	Heat of fusion
C_F	Final value of oxygen concentration
k	Step size between oxygen concentration levels
d	Index factor
%T	Transmittance

**PENGUJIANAN DAN KEBOLEHBAKARAN KOMPOSIT ETHYLENE VINYL
ACETATE (EVA)/ZEOLITE**

ABSTRAK

Tesis ini menerangkan penghasilan, pengujianan dan sifat-sifat zeolite sebagai pengisi dalam komposit ethylene vinyl acetate (EVA). Salah satu objektif utama dalam kajian ini ialah untuk menentukan kesan pembebanan zeolite terhadap sifat-sifat matriks EVA komposit. Komposit EVA yang terdiri daripada berlainan pembebanan zeolite (5-25 vol. %) disediakan menggunakan pencampur dalaman Thermo Haake Polydrive dan kemudian diacu mampatan mengikut piawaian. Ujian tegangan dan dinamik mekanikal analisis telah dijalankan bagi menguji sifat mekanikal komposit EVA/zeolite. Penurunan kekuatan tegangan dan pemanjangan boleh diterangkan melalui mikrograf permukaan patah disebabkan tegangan menggunakan analisis pengimbas elektron mikroskopi. Disamping itu, kesan pengubahsuaian permukaan ke atas sifat-sifat komposit EVA/zeolite telah disiasat. Interaksi antaramuka di antara EVA dan zeolite diubahsuai melalui silang-hubung EVA dengan dicumyl peroxide (DCP); kaedah kation pertukaran dengan surfaktan organik (octadecylamine) dan juga rawatan silane menggunakan 3-aminopropyltriethoxysilane (AMPTES). Tambahan pula, analisis spektra Fourier Transform Infra Merah (FTIR) telah dijalankan untuk mengkaji interaksi di antara komposit dan kumpulan berfungsi pengubah permukaan. Aplikasi pengubahsuaian permukaan telah dibuktikan dapat meningkatkan sifat-sifat mekanikal dan morfologikal komposit EVA/zeolite. Sifat haba komposit

juga diuji dengan analisis thermogravimetric (TGA) dan kebezaan pengimbasan kalorimeter (DSC). Sistem perencat api intumescent yang mengandungi ammonium polyphosphate (APP)/ pentaerythritol (PER) telah digunakan bagi meningkatkan sifat haba dan perencatan kebakaran komposit EVA/zeolite. Sifat mekanikal yang diuji melalui ujian regangan menunjukkan penambahan kedua-dua perencat api menyebabkan penurunan sifat regangan dan pemanjangan komposit EVA/zeolite. Walaubagaimanapun, modulus regangan komposit meningkat dengan ketara kerana ketegaran partikel APP. Keputusan DSC dan TGA menunjukkan kedua-dua perencat api telah meningkatkan kestabilan haba komposit. Keputusan ujian pembakaran menegak (UL-94-V) dan indeks oksigen had (LOI) menunjukkan perencat api dapat menurunkan kebolehbakaran komposit dengan mencapai tahap V-0 UL94-v dan meningkatkan nilai LOI.

**CHARACTERIZATION AND FLAMMABILITY OF ETHYLENE VINYL ACETATE
(EVA)/ZEOLITE COMPOSITES**

ABSTRACT

This thesis describes the fabrication, characterization and properties of natural zeolite as filler in ethylene vinyl acetate (EVA) composites. One of the main objectives of this research is to determine the effect of zeolite loading on properties of EVA matrix composites. EVA composites at different loading of zeolite (5-25 vol. %) were prepared using Thermo Haake Polydrive internal mixer and were then compression molded according to standard test specimen. Tensile test and dynamic mechanical analysis (DMA) were performed to characterize the mechanical properties of EVA/zeolite composites. The tensile test can also be explained from the analysis of Scanning Electron Microscopy (SEM) micrograph of the tensile fractured surfaces. Besides, the influences of surface modifications on the properties of EVA/zeolite composites were also investigated. The interfacial interactions between EVA and zeolite were modified by crosslinking of EVA with dicumyl peroxide (DCP); cation exchange method using organic surfactant (octadecylamine) and also silane treatment using 3-aminopropyltriethoxysilane (AMPTES). In addition, Fourier Transform Infra red (FTIR) spectra analyses were performed in order to study the interaction between the composites and functional group of the surface modifiers. The application of surface modifications was proved to enhance the mechanical and morphological properties of EVA/zeolite composites. Thermal properties of the composites were also characterized by means of thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC). Intumescent flame retardant system consisting of ammonium polyphosphate (APP)/ pentaerythritol (PER) was used to enhance the thermal properties and fire retardancy of EVA/zeolite composites. The mechanical properties examined by tensile test indicated that the introduction of both flame retardants lead to deterioration of tensile strength and elongation at break of EVA/zeolite composites. However, the tensile modulus of the composites was significantly enhanced attributed to the rigidity of APP particles. The results of DSC and TGA

showed that both types of flame retardants have the ability to enhance the thermal stability of EVA/zeolite composites. Meanwhile the results of vertical burning testing (UL-94-V) and limiting oxygen index (LOI) measurement revealed that the flame retardants could also reduce the flammability of the composites by achieving V-0 UL94-v rating and increased LOI value, respectively.

APPENDIX

LIST OF PUBLICATIONS

Journal:

1. Zaharri, N. D, Othman, N., Mohd Ishak, Z.A., (2011) Influence of surface modifications on interfacial interaction of zeolite filled polymer composites, *Key Engineering Materials*, Vol 471-472: 320-324. Transtech Publications Switzerland.
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2. Othman, N., Zaharri, N.D., (2010) Mechanical properties of zeolite filled ethylene vinyl acetate composites crosslinked by peroxide, *The 7th Asian-Australasian Conference on Composite Materials (ACCM7 2010)*, Nov 15 -18, 2010, Taipei, Taiwan.
3. Zaharri, N. D, Othman, N., Mohd Ishak, Z.A., (2011) Influence of surface modifications on interfacial interaction of zeolite filled polymer composites, *8th International*

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