

# PENGESAHAN PENYELIA

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# DEGRADATION BEHAVIOR OF PVC-LDPE BLEND

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Laporan ini diserahkan kepada Fakulti Kejuruteraan Mekanikal sebagai memenuhi sebahagian daripada syarat penganugerahan Ijazah Sarjana Muda Kejuruteraan Mekanikal (Struktur dan Bahan)


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## DECLARATION

I, Chin Su Fok, declare that the Projek Sarjana Muda entitled degradation behavior of PVC-LDPE blend is my own work except some of the article that I declare in the reference

Signature

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: 12/04/2007

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## ABSTRACT

In this study PVC-LDPE blend from pellet form were mixed in an internal mixer at a variation of temperature (160/170/190/190, 160/170/200/200, 160/170/210/210). In this process, the polymer blend was applied with the Hot Isostatic Press at  $142\text{kg/m}^3$  to obtain homogeneous thickness. Specimens were cut to the size for further analysis. Mechanical testing via tensile test as per ASTM D638 and Impact test as per ASTM D 6110 was carried out to investigate the effect of thermal degradation. SEM analyses were conducted to analyze the dispersion of PVC and LDPE in the polymer blend. It was found that the polymer blend with ratio of 60:40 PVC-LDPE with processing temperature of  $210^\circ\text{C}$  has biggest degree of degradation, where the tensile strength obtained of  $5.05\text{MPa}$

## ABSTRAK

Di dalam kajian ini, campuran polimer PVC-LDPE yang dihasilkan daripada bentuk 'pellet' telah dicampurkan di dalam pengadun dalaman (Internal Mixer) pada julat suhu tertentu iaitu (160/170/190/190, 160/170/200/200, 160/170/210/210). Di dalam proses ini, campuran polimer tersebut dikenakan tekanan isostatic panas pada suhu  $142\text{kg/m}^3$  untuk mendapatkan ketebalan yang seragam. Specimen dipotong mengikut size tertentu untuk tujuan analysis berikutnya. Ujian mekanikal melalui Ujian Tegasan mengikut piawaian ASTM D 638 dan Ujian Hentaman mengikut piawaian ASTM D 6110 dijalankan untuk mengkaji corak penyerakan polimer PVC dan LDPE di dalam campuran penyerakan polimer PVC dan LDPE di dalam campuran polimer tersebut. Didapati bahawa campuran polimer dengan nisbah 60:40 PVC-LDPE pada suhu  $210^\circ\text{C}$  mempunyai nilai degradation yang terbesar iaitu 5.05MPa

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# CHAPTER 1

## INTRODUCTION

Poly (vinyl chloride) (PVC) has an excellent combination of low cost, versatility, and properties. When properly formulated, PVC can be obtained in both flexible and rigid forms that are strong and relatively inert to a wide range of environmental conditions. However, improvements in processability, heat distortion temperature, impact strength, and service life have long been sought. Thus much attention has been given to the modification of PVC, originally by copolymerization, and more recently by blending other resins. As the emphasis of polymer science and technology continues to move away from wholly new monomers and towards modification of old ones, even greater attention to both the basic and applied aspects of PVC modification may be expected.

## 1.1 Polyvinyl chloride (PVC)

Poly(vinyl chloride) (PVC) is one of the most widely used plastics that can be processed to form both flexible and rigid finished articles. The production of PVC articles in most processes (such as injection molding and extrusion) generates substantial quantities of scrap which would likely be re-used or recycled. One of the major problems when recycling or re-using the PVC scrap is thermal degradation. The degradation of PVC proceeds by a dehydrochlorination process which results in the formation of long conjugated double bonds or polyene sequences  $(-\text{CH}=\text{CH}-)_n$ , thereby causing a color change. The dehydrochlorination process becomes even more rapid in the presence of oxygen, which then causes in the formation of carbonyl groups. The polyene sequences formed during the degradation can lead to cross linking and chain scissions

## 1.2 Principles of PVC modification

Regardless of whether copolymerization or polyblending is used, the aim is to improve some property without undue loss in others. Also it is sometimes possible to achieve a synergistic improvement to a level higher than that of either polymer component. Typically the aim is to alter the viscosity response of the polymer to raise or to lower the glass temperature ( $T_g$ ) or heat distortion temperature (HDT), to lower the melt flow point or melt viscosity, to increase ductility, solubility and to increase the fracture energy. Interestingly, different laws of additive apply depending on the degree of homogeneity.



### 1.3 Aims of Work

- In view of the continued and increasing importance of polymer blends as a means of economically developing new materials with desirable properties, the current works aimed at the following:
- To prepare several binary PVC blend systems based on conventional PVC and PE that are suitable for film or solid-state applications.
- The effect of thermal degradation on the mechanical properties will be analyzed via mechanical testing (Tensile Test and Impact test )
- The dispersion of particles and the particle size will be determined via Scanning Electronic Microscope (SEM)

### 1.4 Planning & Execution (PSM)

Week Research Activities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Literature Review	■	■	■	■	■	■	■									
Processing Process								■	■	■	■					
Specimen Cutting												■				
Mechanical Testing													■	■		
SEM Study															■	
Morphology																■

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Thermoplastic

A thermoplastic is a material that is plastic or deformable, melts to a liquid when heated and freezes to a brittle, glassy state when cooled sufficiently. A thermoplastic material will flow at elevated temperature above the glass transition temperature or crystalline melting temperature point and the solidified of polymer can be reheated as many times as desire. When the temperature is raised above the glass&-transition temperature ( $T_g$ ) or melting point  $T_m$ , the polymer become easily to formed or molded into desired Shapes. The increased temperatures weaken the secondary bonds in which through thermal vibration of the long molecules and the adjacent chain can thus move more easily under the shaping forces. Then cool the polymer, its return to it originals hardness and strength. [1]

## 2.2 Thermosets

Thermosetting plastics (thermosets) are polymer materials that cure, through the addition of energy, to a stronger form. The energy may be in the form of heat, through a chemical reaction, or irradiation.

When the long chain molecules in polymer have taken place, usually at high temperature, the object can no longer be shaped. Because heat causes the crosslinking which makes the shape permanent,[2]. The long chain molecules are cross-linked in a 3-D arrangement; the structure in effect becomes one giant molecule with strong covalent bonds

Thermoset materials are generally stronger than thermoplastic materials due to this 3-D network of bonds, and are also better suited to high-temperature applications up to the decomposition temperature of the material. They do not lend themselves to recycling

## 2.3 Low Density Polyethylene

Polyethylene has a very simple structure refer to figure 1, the simplest of all commercial polymers. A molecule of polyethylene is a long chain of carbon atoms, with two hydrogen atoms attached to each carbon atom. [3]  
Sometimes some of the carbons, instead of having hydrogens attached to them, will

have long chains of polyethylene attached to them. Refer to figure 2 this is called branched, or low-density polyethylene, or LDPE. When there is no branching, it is called linear polyethylene, or HDPE.

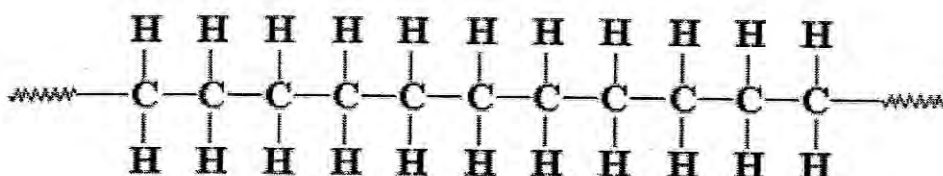
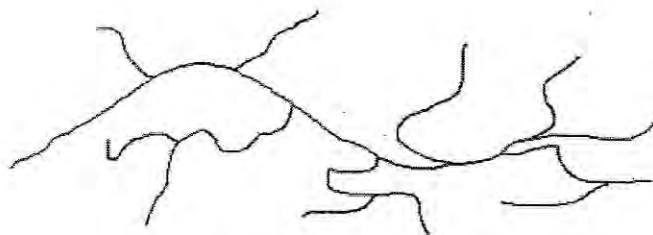


Figure 1: Low density Polyethylene long chain



A molecule of linear polyethylene, or HDPE



A molecule of branched polyethylene, or LDPE

Figure 2: Characteristic of LDPE structure

### 2.3.1 Low Density Polyethylene characteristic

In general, polyethylene is divided into several categories depending on their density and their properties are illustrated as shown on table 1

The difference between the low and high densities lies primary on the structure variations. High density grades crystallize to a much greater degree than low densities [4]

Table 1 Principle properties of difference type of polyethylene

Property	HDPE	LDPE	LLDPE	VLDPE	EVA	Ionomer
Density (g/cm <sup>3</sup> )	0.94-0.97	0.91-0.94	0.90-0.94	0.86-0.90	0.92-0.94	0.93-0.96
Degree of crystallinity (% from density)	62-82	42-62	34-62	4-34	—	—
Degree of crystallinity (% from calorimetry)	55-77	30-54	22-55	0-22	10-50	20-45
Flexural modulus (psi @ 73°F)	145,000-225,000	35,000-48,000	40,000-160,000	<40,000	10,000-40,000	3,000-55,000
Tensile modulus (psi)	155,000-200,000	25,000-50,000	38,000-130,000	<38,000	7,000-29,000	<60,000
Tensile yield stress (psi)	2,600-4,500	1,300-2,800	1,100-2,800	<1,100	5,000-2,400	—
Tensile strength at break (psi)	3,200-4,500	1,200-4,500	1,900-6,500	2,500-5,000	2,200-4,000	2,500-5,400
Tensile elongation at break (%)	10-1,500	100-650	100-950	100-600	200-750	300-700
Shore hardness Type D	66-73	44-50	55-70	25-55	27-38	25-66
Izod impact strength (ft-lb/in. of notch)	0.4-4.0	No break	0.35-No break	No break	No break	7.0-No break
Melting temperature (°C)	125-132	98-115	100-125	60-100	103-110	81-96
Heat distortion temperature (°C@66 psi)	80-90	40-44	55-80	—	—	113-125
Heat of fusion (cal/g)	38-53	21-37	15-43	0-15	7-35	14-31
Thermal expansivity (10 <sup>-6</sup> in/in/°C)	60-110	100-220	70-150	150-270	160-200	100-170

### 2.3.2 The advantage and disadvantageous of low density polyethylene (LDPE) [5]

Table 2 Advantage and disadvantage of LDPE

Advantage	Disadvantages
Inexpensive Easily processed Good chemical resistance	1. Poor resistance to weathering

### 2.3.3 Application of Low Density Polyethylene

Polyethylene was use in the house good because good chemical resistance, food packaging and containers because of easy process and inexpensive.[6]

## 2.4 Polyvinyl chloride (PVC)

Refer to fig polyvinyl chloride is made by reacting acetylene gas ( $C_2H_2$ ) with hydrochloric acid in the presence of suitable catalyst in the polymerization of the monomer vinyl chloride [7]

PVC can be plasticized and unplasticized. Plasticized was use to make it flexible for use in flooring and medical products. Rigid PVC or PVC-U ("unplasticised") is used extensively in building applications such as window frames. Melt and rigid PVC cannot truly melt molecular scale without degradation [9]

PVC is intrinsically fire retardant because of the presence of chlorine in the polymer matrix. PVC has excellent electrical insulation properties, and good impact strength and weatherproof attributes.

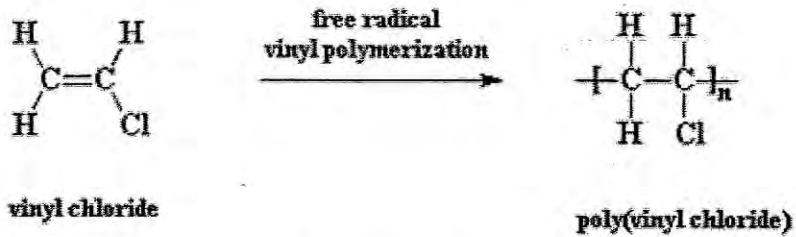


Figure 3 Polyvinyl chloride (PVC) characteristic [8]

### 2.4.1 Typical properties of Polyvinyl chloride

Table 3 Typical properties of Polyvinyl chloride

Polyvinylchloride	
Maximum Temperature:	158°F 70°C
Minimum Temperature:	-13°F -25°C
Autoclavable:	No
Melting Point:	212°C
Tensile Strength:	6,500 psi = 44.8159kPa
UV Resistance:	Good
Clear	Yes
Rigid	Yes

## **2.5 Factor affecting the properties and characteristic of polymer**

There are four main characteristic that can influence the polymer blend and the thermal degradation. The characteristic are crystallinity and amorphous phase, melt viscous flow, glass transition temperature and melt temperature

### **2.5.1 Crystallinity and amorphous phase**

There are three conditions in the polymer structure which are crystallinity, amorphous and semicrystalline refer to figure 4 Polymer crystallinity can be described as the packing of the molecular chains so as to produce an ordered array [11]. Amorphous can be described as having no ordered arrangement. Polymer amorphous can be category when their chains are tangled up in any old way. Polymers are not amorphous when their chains are lined up in ordered crystals. Semicrystalline can be described as polymer of having properties of crystalline and amorphous state.

Most polymers are crystalline (semicrystalline), with crystalline region dispersed within the remaining amorphous material. Crystalline region in the polymer make the material stronger but also make the material brittle. The amorphous regions give polymer toughness, that is the ability to bend without breaking.[12]