

# Effects of Compatibilizer Type and Rubber-Wood Sawdust Content on the Mechanical, Morphological, and Thermal Properties of PVC/LDPE Blend

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**ABSTRACT:** This article aimed to investigate the mechanical, morphological and thermal properties of PVC/LDPE blend with and without the addition of compatibilizers. The effects of LDPE content, compatibilizer type and rubber-wood sawdust loading on the properties of the blend were evaluated. The experimental results suggested that as the LDPE content was increased the mechanical properties of PVC-LDPE blend progressively decreased due to poor interfacial adhesion. The continuity and compatibility between PVC and LDPE phases could be improved through three different types of compatibilizers which included chlorinated polyethylene (CPE) poly(methyl-methacrylate-co-butyl acrylate) (PA20) and poly(ethylene-co-methacrylate) (Elvaloy). The PA20 was found to be the most suitable

compatibilizer for the blend. A radical transfer reaction was proposed in this work to explain the structure and thermal changes of the PVC in PVC-LDPE blend. The decomposition temperature of PVC in the blend decreased with the loading of the PA20 and the wood sawdust. As the sawdust content was increased the tensile and flexural moduli increased with considerable decrease in the tensile, flexural and impact strength, a slight improvement being achieved if the PA20 was incorporated in the composite. © 2006 Wiley Periodicals, Inc. *J Appl Polym Sci* 102: 598–606, 2006

**Key words:** polymer blend; poly(vinyl chloride); composite; wood sawdust; mechanical properties

## INTRODUCTION

Wood has been used as a building and engineering material and offers several advantages of not just being esthetically pleasing but also renewable and recyclable. Wood and natural fibers have a number of benefits as reinforcements for synthetic polymers because of their high specific strength and stiffness, relatively low density, biodegradability, and low cost.<sup>1</sup> In addition, wood fibers contribute to the solution of environmental problems caused by the disposing of large volumes of nonbiodegradable materials.<sup>1</sup> Wood-based composites with a continuous polymer phase are now gaining interest, giving the opportunity to process the composite by using conventional thermo-plastic processing equipment. The processing of wood composites also minimizes abrasion of the equipment

due to the low hardness of wood compared to inorganic fillers used in a great number before. Many researchers have studied on composites of homo-polymer and wood or cellulose fibers, the homo-polymers including poly(vinyl chloride),<sup>2–7</sup> polyethylene,<sup>8–11</sup> and polypropylene.<sup>12–15</sup> The main drawback of natural fiber-reinforced polymers is the lack of good interfacial adhesion between fiber and matrix, which results in poor properties of the final products. Therefore, to develop such composites with good mechanical properties, it is necessary to use coupling agents or compatibilizers in the composite systems, the widely used coupling agents including silane coupling agents,<sup>5,9,16–18</sup> maleic-anhydride-grafted-polymers.<sup>8,11,13–15</sup>

It is well known that the binary blend of PVC and LDPE is typically immiscible at molecular level and causes a poor interphase structure and mechanical properties. In this respect, enhancing the compatibility of PVC and LDPE is one of the key technologies to obtain polymer blends with desirable properties. The ideal compatibilizer should contain two domains: one domain being able to form entanglements or segmental crystallization within the polymer matrices and the other being able to form a strong adhesive bond with

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other type of materials. Two possible ways to improve the mechanical properties of PVC/LDPE blend are to add a compatibilizer<sup>19–21</sup> and/or to cocrosslink these two components.<sup>22–24</sup> Ghaffar et al. and Hajian et al.<sup>19,20</sup> suggested that the use of solid phase dispersants such as chlorinated polyethylene (CPE), ethylene-propylene-diene rubber (EPDM), acrylonitrile-butadiene-styrene copolymer (ABS), and polyurethane (PU) could improve the tensile properties of PVC/LDPE and PVC/PS blends. Sombatsompop et al. reported that loading LDPE into PVC led to the formation short-chain LDPE-grafted PVC copolymers through a macroradical cross-recombination reaction.<sup>23</sup> Besides, phase dispersion-crosslinking synergism in the binary blend of PVC/LDPE coexisted with the presence of both dicumyl peroxide (DCP) initiator and solid phase dispersant.<sup>22</sup> The cocrosslinking products and the entrapping phenomenon were also proposed for PVC/LDPE/DCP system.<sup>24</sup> The grafting, cocrosslinking, and entrapping phenomena brought about the improvement of the mechanical and thermal properties in the PVC/LDPE blend.<sup>19–24</sup>

In literatures, either PVC or LDPE has been used separately as a continuous phase and is reinforced by wood and cellulose fibers,<sup>19–23</sup> but the properties of PVC and PE blend incorporating with wood fibers have never been reported. This is very important since PVC is often used as a blend with other types of plastics such as polyethylene in packaging applications. Thus, it is of great interest to examine the properties of PVC/LDPE blend incorporated with natural fibers. This article focused on PVC/LDPE blend and their composite with rubber-wood sawdust. To improve compatibility between PVC and LDPE binary polymer blend, three different types of compatibilizers were used. Mechanical, morphological, and thermal properties of PVC/LDPE blend with and without compatibilizers were then determined. The effects of LDPE and wood sawdust contents on such properties were also studied.

## EXPERIMENTAL

### Raw materials

Poly(vinyl chloride) (PVC, B0504BLA suspension grade,  $K$  value = 66) was supplied by Thai Plastics and Chemicals (Bangkok, Thailand). The compound composed of 1.2 phr calcium stearate, 1.2 phr tetrabasic lead sulfate, 0.1 phr polyethylene wax, and 4 phr calcium carbonate. Low-density polyethylene (LDPE, LD1905F) with MFI of 5 (tested at 21.6 N and 190°C) was obtained from Thai Polyethylene (Bangkok, Thailand). Three compatibilizers were chlorinated polyethylene (CPE-135A with Cl content of 35%), poly(methyl methacrylate-*co*-butyl acrylate) (Acrylic-PA20), and poly(ethylene-*co*-methacrylate) (Elvaloy-1125AC with

25% methacrylate), which were supplied from Serichemical (Bangkok, Thailand), Srithepthai (Bangkok, Thailand), and Chemical Innovation (Bangkok, Thailand), respectively. Rubber-wood sawdust (*Hervea Brasiliensis*), collected from local furniture factory, was sieved through standard sieve of 50–80 mesh, corresponding to the particle length of 180–300  $\mu\text{m}$ . The sieved sawdust was dried in an oven at 105°C for 2 h before use.

### Blend preparation and experimental design

Melt-blending of PVC with LDPE was performed using a single-screw extruder (Thermo Haake Poly Drive) using a screw speed of 60 rpm and a temperature range from 170 to 190°C, starting from feed zone to die zone. The obtained extrudates were further compounded in a two-roll mill (LabTech Engineering, LRM 110) for 10 min using the temperature of 165°C before transferring into a compression molding machine (LabTech Engineering, LP 20). The compressing temperature and time were set at 200°C and 8 min, respectively.

Since this work aimed to study the effects of compatibilizer type and rubber-wood sawdust contents on the properties of the PVC-LDPE blends, the following subworks are noted. Firstly, the amount of the LDPE was varied at 0, 10, 20, 30, 40, and 50 phr to study the effect of LDPE content on the properties of the PVC/LDPE blends. Secondly, three different compatibilizers, including CPE, PA20, and Elvaloy-1125AC, were used and added at a fixed amount of 15% by weight into the PVC-LDPE blend having a constant LDPE amount of 10 phr. Finally, the wood sawdust content was varied from 0 to 50%.

### Mechanical properties

All mechanical tests were carried out at the temperature of  $(23 \pm 1)^\circ\text{C}$  and relative humidity of  $(50 \pm 5)\%$ . Tensile test was conducted according to ASTM D-638. The tensile measurements from dumbbell specimens were carried out using Universal Testing Machine (LLOYD Instrument, LR 5k) using WINDAP software with 5 kN load cell and a crosshead speed of 5 mm/min. For flexural property, ASTM D-790 was used as a reference. Three-point bending test was set up in the Universal Testing Machine to examine the flexural modulus and strength of the PVC-LDPE blends and sawdust-PVC-LDPE composites using a rectangular specimen. Span length used was 40 mm and the compression speed was 5 mm/min using 5 kN load cell. Izod impact tester (Yasuda Seiki Seisakusho, 258-PC) was used to evaluate the impact strength of the blends and the composites. The notched testing specimens were used following the ASTM D-256. The impact property results were reported in terms of impact

**TABLE I**  
**Mechanical Properties of PVC/LDPE Binary Blend with Different Contents of LDPE**

PVC/LDPE ratio	Young's modulus (MPa)	Tensile strength (MPa)	Elongation-at-break (%)	Flexural modulus (MPa)	Flexural strength (MPa)	Impact strength (kJ/m <sup>2</sup> )
100/0	72 ± 18	38.6 ± 1.6	178.2 ± 38.7	2763 ± 386	67.1 ± 6.6	78.5 ± 6.1
100/10	45 ± 15	31.5 ± 1.5	57.7 ± 21.8	2599 ± 216	47.3 ± 3.3	58.9 ± 5.8
100/20	41 ± 14	21.5 ± 2.7	29.8 ± 11.8	1010 ± 133	40.4 ± 3.1	4.6 ± 1.4
100/30	34 ± 12	16.1 ± 1.6	28.3 ± 4.5	653 ± 28	25.3 ± 1.7	2.7 ± 0.6
100/40	33 ± 11	12.6 ± 1.5	18.9 ± 3.0	645 ± 70	23.4 ± 1.2	2.0 ± 0.5
100/50	31 ± 10	8.0 ± 1.3	17.1 ± 3.3	585 ± 69	15.9 ± 1.4	1.9 ± 0.4

energy divided by the area of the specimen (kJ/m<sup>2</sup>). It should be noted that the mechanical property results of the composites reported in this work were obtained by averaging from ten independent tested specimens.

### Thermal properties

Glass transition temperatures of the samples were evaluated using a shear-bending mode dynamic mechanical analyzer (DMA, Merrier Teledo DMA/SDTA 861) at a temperature range from 20 to 130°C with a heating rate of 4°C/min and a fixed frequency of 1 Hz. In addition, thermal decomposition temperatures of the blends and the composites were carried out using thermal gravimetry TGA (Perkin-Elmer, Pyris 1). The specimen was tested under nitrogen atmosphere using a temperature range of 35–700°C and a heating rate of 10°C/min. The thermal degradation temperatures were reported by the onset temperature where the weight loss started to occur.

### Scanning electron microscopy

A LEO 1455 VP scanning electron microscopy was employed to study the interfacial morphology and phase dispersion of the PVC/LDPE blends and their composites. The samples were immersed in a nitrogen liquid before fractured. After that the samples were sputter-coated with a thin layer of gold to prevent electrical charging during the observation. The surface characteristics were examined and operated at 6 kV accelerating voltage.

## RESULTS AND DISCUSSION

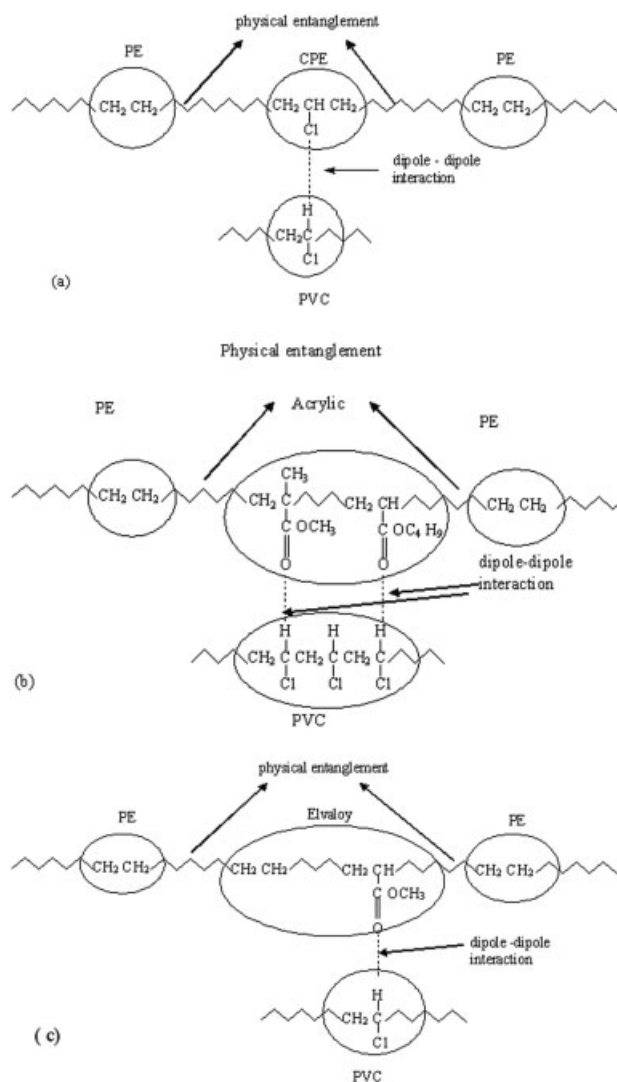
### Effect of compatibilizer type in PVC-LDPE blend

It is reasonable to assume that no chemical adhesion exists between PVC and LDPE in the blend.<sup>19–24</sup> As can be seen in Table I, incorporation of LDPE into PVC resulted in significant changes in tensile, flexural, and impact properties. The Young's modulus of the blend decreased with increasing LDPE content. This was expected due to the fact that the LDPE is softer phase in nature as compared to PVC rigid phase. It was observed that the tensile strength and elongation at break of the blend progressively decreased with LDPE content due to poor interfacial adhesion, the LDPE phase acting as defects and disturbing the continuity of the PVC matrix phase. Similar to tensile properties, the flexural and impact properties of the blend significantly dropped as a result of increasing LDPE content in the PVC matrix. The reductions in the mechanical properties suggested poor interfacial adhesion between the PVC and LDPE phases. Considering the impact strength, which reflected an ability of the blend to receive and transfer a sudden shock load or mechanical energy across a given cross section to failure, it was observed that by adding LDPE content of greater than 10 phr, the reduction in the impact strength became more apparent. This was probably associated with phase compatibility or continuity level in the PVC-LDPE blend.

To overcome the poor interfacial bonding of the incompatible PVC and LDPE blend, three different compatibilizers were introduced; these being CPE,

**TABLE II**  
**Mechanical Properties of PVC/LDPE Binary Blend for Different Types of Compatibilizers**

Mechanical properties	Compatibilizer in PVC/LDPE blend			
	No compatibilizer	15% CPE	15% PA20	15% Elvaloy
Young's modulus (MPa)	43.7 ± 8.3	124.9 ± 24.6	138.9 ± 46.9	121.1 ± 35.4
Tensile strength (MPa)	31.5 ± 1.5	33.4 ± 1.8	33.8 ± 1.4	32.0 ± 0.3
Elongation-at-break (%)	57.7 ± 21.8	133.3 ± 37.7	104.4 ± 38.3	138.7 ± 20.8
Flexural modulus (MPa)	1598 ± 315	1982 ± 137	1993 ± 169	1523 ± 400
Flexural strength (MPa)	47.3 ± 3.3	50.8 ± 1.5	48.6 ± 1.9	52.6 ± 3.4
Impact strength (kJ/m <sup>2</sup> )	58.9 ± 5.8	64.6 ± 4.2	78.7 ± 6.9	70.1 ± 6.1



**Figure 1** Proposed compatibilizing mechanism in PVC-LDPE blend system with various compatibilizers: (a) CPE, (b) PA20, and (c) Elvaloy.

PA20, and Elvaloy. The blend ratio of the PVC/LDPE was fixed at 100/10 and 15 wt % of the compatibilizers was used for each compatibilizer. Table II shows the effect of compatibilizer type on the mechanical prop-

**TABLE IV**  
Effect of Compatibilizer Type on Glass-Transition Temperature of PVC in PVC/LDPE Blend

Blend system	Glass-transition temperature of PVC in PVC/LDPE blend (°C)
PVC	91.4
PVC/LDPE (100/10)	88.5
PVC/LDPE (100/10) + 15% CPE	87.7
PVC/LDPE (100/10) + 15% PA20	90.3
PVC/LDPE (100/10) + 15% Elvaloy	88.8

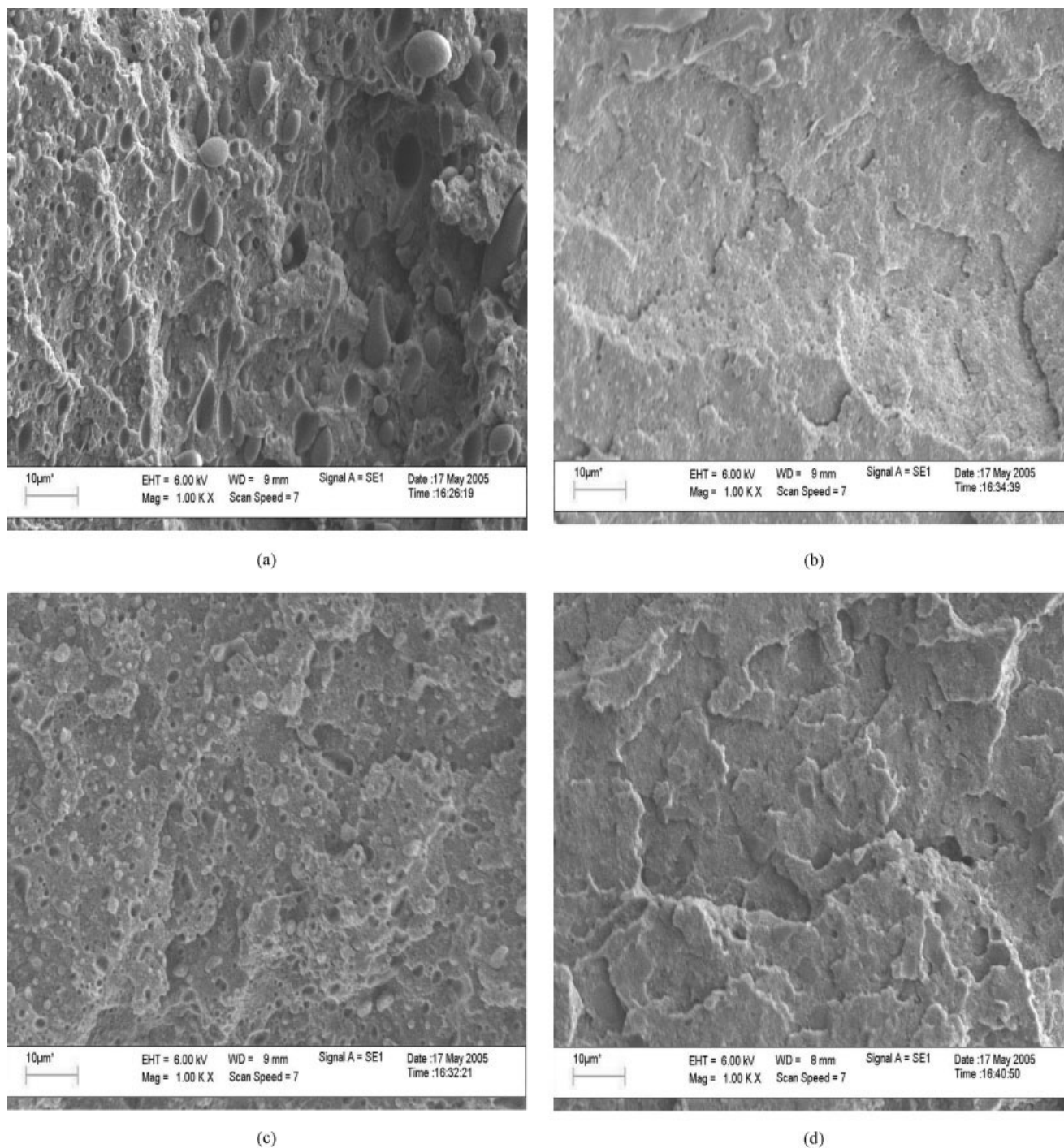
erties of the PVC-LDPE blend and suggested that all the compatibilizers improved the mechanical properties of the blend. This could be explained on the basis of the improved compatibility between PVC and LDPE phases. In this work, the compatibilizing mechanism of each compatibilizer in the PVC-LDPE blend was proposed as shown in Figure 1. The purpose of this was to explain the property differences of the blend caused by introducing different compatibilizers into the blend. It can be seen that the CPE has a similar chemical structure to both PVC and LDPE and it can form a dipole-dipole interaction with PVC and a physical chain entanglement with LDPE [Fig. 1(a)]. The PA20 in Figure 1(b) is composed of poly(methyl methacrylate) and poly(butyl acrylate) and the long vinyl chains in the molecule can be compatible with LDPE phase, while the polarity of the PMMA and PBA molecules form a dipole-dipole interaction with PVC phase. The Elvaloy is a copolymer between ethylene and methacrylate monomers, which can be compatible with LDPE and PVC as shown in Figure 1(c), respectively. Table III illustrates percentage differences in the mechanical properties of PVC/LDPE blend containing the three compatibilizers at 10 phr LDPE. In general, it was observed that the PA20 had more effect on the mechanical property improvement of the blend as compared with the other two compatibilizers. The compatibilizing effect of PA20 over that of CPE and Elvaloy can be supported by glass-transition temperature ( $T_g$ ) results shown in Table IV. It can

**TABLE III**  
Percentage Differences in Mechanical Properties of PVC/LDPE Binary Blend using Different Compatibilizers

Properties	Compatibilizer in PVC/LDPE blend <sup>a</sup>			
	15% CPE	15% PA20	15% Elvaloy	7.5% CPE and 7.5% PA20
Young's modulus	176	207	204	168
Tensile strength	5.90	7.30	1.40	1.80
Elongation at break	131	81	140	150
Flexural modulus	24	25	1.20	19.40
Flexural strength	7.50	2.70	11.10	7.30
Impact strength	9.70	34	17.10	19.10

<sup>a</sup> Values given are percentage values.





**Figure 2** SEM micrographs of PVC/LDPE blend with different compatibilizers: (a) no compatibilizer, (b) CPE, (c) PA20, and (d) Elvaloy.

be seen that the addition of PA20 into the PVC/LDPE blend shifted the  $T_g$  to higher temperature about  $2^\circ\text{C}$  as compared to the blend without compatibilizers. This was not the case for the blends with CPE and Elvaloy compatibilizers. This suggested that PA20 could act as a better compatibilizer for the PVC/LDPE blend. It was also interesting to note that the  $T_g$  of the blend with PA20 was very close to that for neat PVC.

The effect of PA20 as a compatibilizer in PVC composites could further be substantiated by Mengeloglu et al.,<sup>25</sup> who observed that the impact strength of PVC/wood-fiber composites could be improved through an addition of acrylic-based modifier, and by Sombatsompop and Phromchirasuk,<sup>7</sup> who found that incorporation of PA20 in PVC-wood composites enhanced the tensile and ultimate elongation of the com-

**TABLE V**  
**Effect of Compatibilizer Type on Decomposition**  
**Temperature of PVC in PVC/LDPE Blend**

Blend system	Decomposition temperature of PVC in PVC/LDPE blend (°C)
PVC	287.6
PVC/LDPE (100/10)	291.3
PVC/LDPE (100/10) + 15% CPE	284.0
PVC/LDPE (100/10) + 15% PA20	289.9
PVC/LDPE (100/10) + 15% Elvaloy	281.1

posites. Thus, it could be said that the PA20 was suitable and could be used as both compatibilizing and impact-modifying agents. When using a combination of the CPE and PA20 compatibilizers, the overall mechanical properties tended to follow those in the blend with CPE. As expected, the overall mechanical properties of the binary blend with Elvaloy compatibilizer fell in between those with CPE and PA20 compatibilizer, since Elvaloy structure is composed of ethylene and methacrylate monomers, roughly resembling the molecular structures of the CPE and PA20 compatibilizers. It was very important to highlight, since this article aimed to improve the compatibility of the PVC and LDPE phases incorporated with rubber-wood sawdust particles, the relevant mechanical properties probably involve elastic (tensile and flexural modulus) and impact strength. Taking the properties in Tables II and III into account, it can be preliminarily concluded that the compatibilizers could be used to improve the continuity and compatibility between PVC and LDPE phases and thus enhance mechanical properties, and the PA20 appeared to be the most suitable compatibilizer for these specific applications.

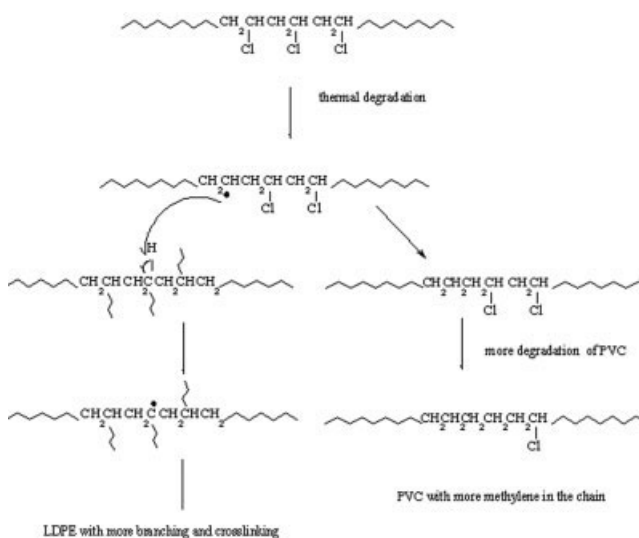
The improved continuity and compatibility between PVC and LDPE phases could be substantiated by considering the SEM micrographs of PVC-LDPE blends with and without the compatibilizers, whose results are shown in Figures 2(a)–2(d). Figure 2(a) represents the fracture surface of PVC-LDPE blend sample without the compatibilizers. It was observed that the LDPE as a disperse phase was located inside the empty voids of the PVC continuous phase, suggesting a poor compatibility between PVC and LDPE phases. When the three compatibilizers [CPE, PA20, and Elvaloy in Figs. 2(b)–2(d)] were used, the phase compatibility appeared to improve, which can be evidenced by smaller interphase boundary between PVC and LDPE components. It was also observed that the particle size of LDPE disperse phase in the PVC continuous phase was smaller than that presented in Figure 2(a). In addition, the fractured surface of the blend with the compatibilizers was smoother than that of the blend with no compatibilizers. This was why the over-

all mechanical properties of the PVC-LDPE blends were improved by the addition of the compatibilizers.

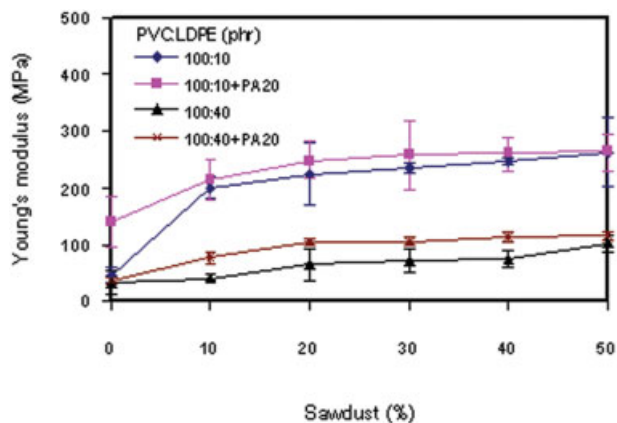
Table V shows the changes in decomposition temperature ( $T_d$ ) of the PVC in PVC/LDPE blend with and without the compatibilizers. It can be seen that the decomposition temperature of the PVC increased when incorporating LDPE into the blend. In this present study, we proposed a unique explanation for the increase in  $T_d$  of the PVC to be associated with a radical transfer reaction between PVC to LDPE molecules during processing. The proposed radical transfer reaction is shown in Figure 3. It can be explained that the PVC macroradicals produced from a dehydrochlorination reaction during melt blending process has promoted degradation of long-chained PE and probably led to a hydrogen abstraction from the PE molecules. The PE macroradicals subsequently underwent a branching, which produced short-side chain formation in LDPE molecule of the blend. If this was the case, the dehydrochlorination of the PVC had less chance to occur and thus more stabilized PVC molecules in the blend.<sup>26</sup> It was interesting to note that the  $T_d$  of the PVC decreased when incorporating the three compatibilizers. This may be expected, since the PVC and LDPE phases became more attached to each other via the compatibilizers. If this was the case, the productions of LDPE and PVC radicals for the radical transfer reaction during processing became minimized, and thus the degradation of the PVC in the blend could take place more easily.

#### Effect of rubber-wood sawdust in PVC/LDPE blend

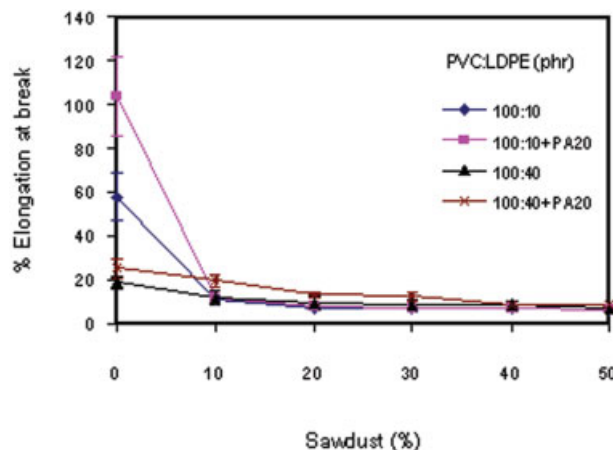
Two selected PVC/LDPE blend ratios (100/10 and 100/40) with PA20 compatibilizer were used to study



**Figure 3** The proposed radical transfer reaction in PVC/LDPE blend.



**Figure 4** Young's modulus of PVC/LDPE blend with and without PA20 for different wood sawdust contents. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com).]



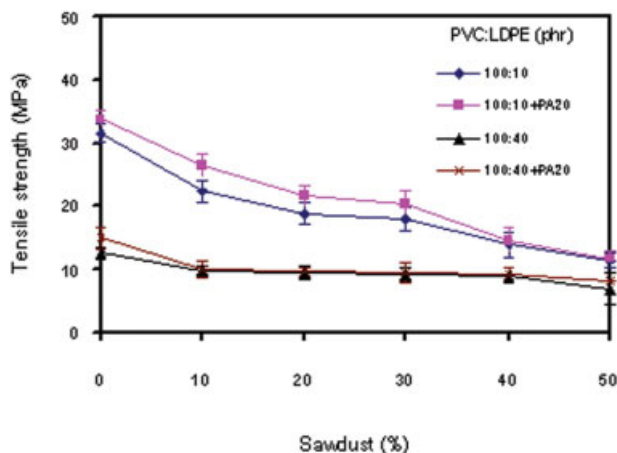
**Figure 6** Elongation at break of PVC/LDPE blend with and without PA20 for different wood sawdust contents. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com).]

the effect of rubber-wood sawdust content on the mechanical properties of the binary blends, the results being shown in Figures 4–9. The overall observations and explanations to the results are listed in fragmenting points as follows:

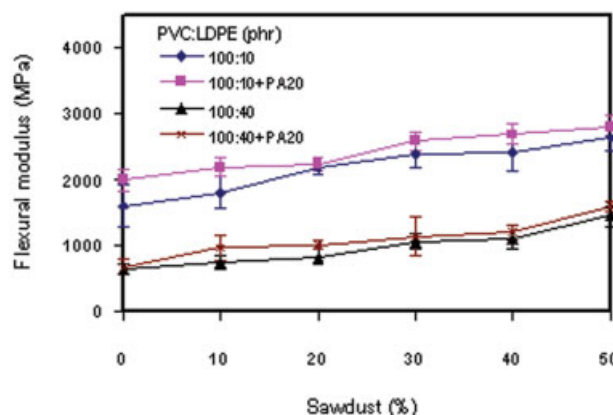
- The tensile and flexural moduli (Figs. 4 and 7, respectively) of the blends increased with increasing sawdust content. Tensile strength (Fig. 5) and elongation at break (Fig. 6), flexural strength (Fig. 8) and impact strength (Fig. 9) of the blends dramatically decreased with 10 phr rubber-wood sawdust content, the properties leveling-off at higher sawdust loadings. The increase in the moduli of the blend with increasing sawdust content was caused by the fact that the sawdust is more rigid phase as compared to the binary

blend. The sharp drops in tensile, flexural, and impact strengths were associated with poor dispersion of the sawdust particles in the blend matrix. It is widely known that the sawdust particles (fibers) tended to cling together due to strong interfiber hydrogen bonding, and resisted dispersion of the individual fiber in the polymer phase, and thus reduced mechanical strength of the blends.<sup>27</sup> It was worth taking note that the mechanical properties of the PVC-LDPE blend stabilized with sawdust loadings of greater than 10 phr. This could be of economical benefit to industries as one could add greater amounts of wood sawdust particles to replace the polymer phase without significant changes in mechanical properties, therefore leading to cost savings.

- The blends with PA20 compatibilizer appeared to have greater mechanical strength than those with-

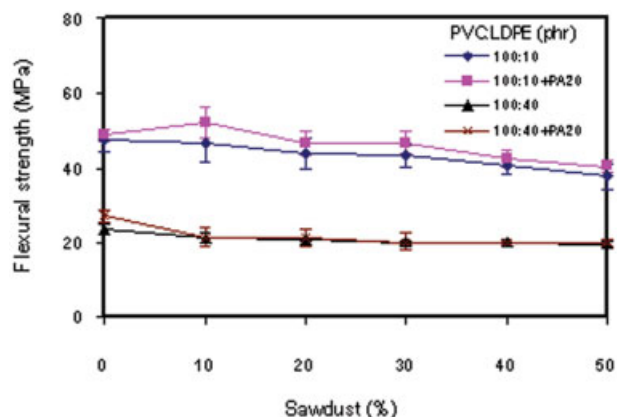


**Figure 5** Tensile strength of PVC/LDPE blend with and without PA20 for different wood sawdust contents. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com).]



**Figure 7** Flexural modulus of PVC/LDPE blend with and without PA20 for different wood sawdust contents. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com).]



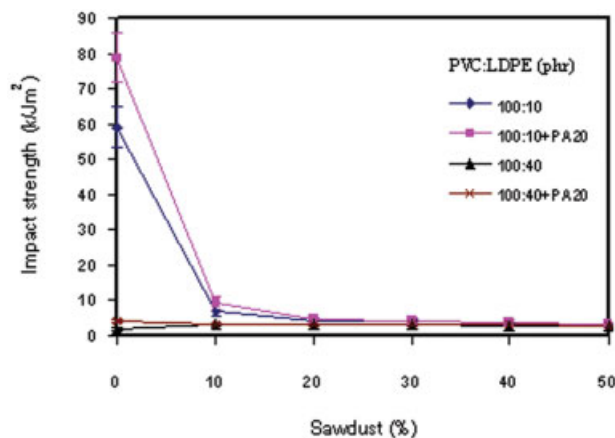


**Figure 8** Flexural strength of PVC/LDPE blend with and without PA20 for different wood sawdust contents. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com).]

out PA20. The compatibilizing mechanism has already been discussed earlier. It was also found that the PA20 could perform more effectively in improving the phase compatibility between PVC and LDPE in the absence of wood sawdust particles.

- The magnitude of the mechanical property reduction as a function of rubber-wood sawdust content of the blend with 10 phr LDPE were greater than those with 40 phr LDPE.

Table VI shows the changes in decomposition temperature ( $T_d$ ) of the PVC in PVC/LDPE (100/10) blend affected by acrylic compatibilizer and wood sawdust. It can be seen that the addition of wood sawdust particles caused an enormous reduction in the  $T_d$  of the PVC to about 40°C. However, the decomposition temperature of the PVC in the composites was im-



**Figure 9** Impact strength of PVC/LDPE blend with and without PA20 for different wood sawdust contents. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com).]

**TABLE VI**  
Effect of PA20 and Rubber-Wood Sawdust on Decomposition Temperature of PVC in PVC/LDPE Blend

Blend system	Decomposition temperature of PVC in PVC/LDPE blend (°C)
PVC	287.6
PVC/LDPE (100/10)	291.3
PVC/LDPE (100/10) + 15% PA20	289.9
PVC/LDPE (100/10) + 10% sawdust	243.7
PVC/LDPE (100/10) + 15% PA20 + 10% sawdust	254.0

proved by the addition of PA20. It was also noticeable that adding PA20 slightly increased the  $T_d$  of PVC in the PVC-LDPE blend, the  $T_d$  reduction being very remarkable in the wood-sawdust/PVC-LDPE composites. The sharp reduction in the  $T_d$  value by addition of wood sawdust was probably related to incompatibility between the hydrophilic wood sawdust and the hydrophobic PVC and LDPE molecules. Besides, previous work<sup>6,27</sup> has suggested that increasing the sawdust content could result in a reduction of the decomposition temperature of the PVC, the reasons being associated with the hydrogen bonding in the hydrophilic sawdust, which could cleave Cl atom from the PVC and thus reduce thermal stability of the PVC in the blend.<sup>27</sup>

## CONCLUSIONS

The mechanical and thermal properties PVC/LDPE blends affected by additions of three different compatibilizers and rubber-wood sawdust were studied. It was found that the mechanical properties of PVC-LDPE blend decreased with increasing LDPE loadings due to phase incompatibility. All the compatibilizers (CPE, PA20, and Elvaloy) used in this work improved the continuity and compatibility between PVC and LDPE phases and thus enhanced the mechanical properties of the blend. The PA20 was found to be the most suitable compatibilizer for the blend. The structural and thermal changes of the PVC in the blend were explained via a radical transfer reaction. The decomposition temperature of the PVC in the blend decreased with the additions of the compatibilizer and the wood sawdust particles. As the sawdust content was increased, the tensile and flexural moduli increased with considerable decreases in the tensile, flexural, and impact strength, a marginal improvement being observed if the PA20 was incorporated. Adding PA20 into the blend decreased the  $T_d$  of PVC slightly in the PVC-LDPE blend, but remarkably in the wood-sawdust/PVC-LDPE composite. It was observed that the PA20 could perform more effectively



in improving the phase compatibility between PVC and LDPE in the absence of wood sawdust particles.

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