# EFFECT OF COMPATIBILIZER ON MECHANICAL PROPERTIES AND MORPHOLOGY OF CLAY FILLED LOW DENSITY POLYETHYLENE (LDPE) COMPOSITES

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**Abstract:**

The main purpose of incorporating fillers, such as clay into composites of polyolefin is to decrease costs and change the properties. Structural differences between both components give rise to the formation of large filler agglomerates in the polymer matrix, which influence the mechanical response of the materials. Clay was used as a filler in LDPE composites and Polyethylene Acrylic Acid (PEAA) was used in this study as a compatibilizer. The effect of filler loading and PEAA on the mechanical and morphology of the composites were investigated. It was found that incorporation of compatibilizer (PEAA) increased the tensile strength and Young's modulus but decreased the elongation at break. Scanning electron microscopy (SEM) study of the tensile fracture surface of the composites indicated that the presence of PEAA increased the interfacial interaction between clay and LDPE matrix.

**Keywords**: Low density polyethylene, clay, compatibilizer, composites.

## Introduction

The incorporation of mineral fillers into thermoplastics has been widely practical in industry to extend them and to enhance certain properties. Fillers often increase the performance of polymeric product. The addition of fillers to polymers is a fast and cheap method to modify the properties of the base materials. For this reason, particulate filled polymers have been, and are, a subject of increasing interest in both industry and research. Researchers as Maiti et al., Zoltan et al. [1-2], Suwanprateeb et al [3], Gonzalez et al [4] have reported that the addition of a filler to polymer system results in a deterioration of breaking and impact resistance: this behavior has been attributed to weakness in the structure of these two-phase system cause by stress concentration or discontinuity in stress transfer at narrow portion of the matrix at the dispersed phase and matrix. This poor interaction between both components has given rise to the formation of large filler agglomerates in polymer matrix, markedly influencing the mechanical properties response of the finished materials. In this study, the effect of clay loading and compatibilizer (PEAA) on tensile properties of low density polyethylene composites was studied.

## Experimental

*Materials*

Polyethylene used was a low density polyethylene (LDPE) grade L705 (MFI 7 g/10 min and density 0.918 g/cm$^3$) was obtained from Polyolefins Company, Singapore. Clay with average particle size 9.4µm was obtained by Ipoh Ceramic Sdn Bhd. Polyethylene co Acrylic Acid (PEAA) was obtained from Aldrich Chemical Company. The formulation of LDPE/clay composites used in this study is shown in Table 1.

Table 1. Formulation of LDPE/clay composites with different filler loading

| **Materials** | **Uncompatibilised Composites** | **Compatibilised Composites** |
|---|---|---|
| LDPE (php)* | 100 | 100 |
| Clay (php)* | 0, 10, 20, 30, 40 | 0, 10, 20, 30, 40 |
| PEAA (php)* | - | 3 |

*per 100 part of polymer

*Mixing Procedure*

The mixing of uncompatibilised and compatibilised of LDPE/Clay composites was carried out in a Z-Blade Mixer at 180 ºC. LDPE was first charged to start the melt mixing. After 7 min clay was added followed by PEAA. Mixing was continued for another 5 minutes. At the end of 12 min, the composites were taken out and sheeted through a laboratory mill at 2.0 mm nip setting. Sample of composites were compression molded in an electrically heated hydraulic press. Hot-press procedures involved preheating at 180 $^{0}$C for 6 min followed by compressing for 4 min at the same temperature and subsequent cooling under pressure for 4 min.

*Measurement of Tensile Properties*

Tensile test were carried out according to ASTM D-638 an Instron machine. 1 mm thick dumb bell specimens were cut from the molded sheets with a Wallace die cutter. A cross-head speed of 50mm/min was used and the test was performance at 25± 3 ºC.

*Morphology Study*

Studies on the morphology of the tensile fracture surface of the composites were carried out using a scanning electron microscope (SEM), model JSM 6260 LE JOEL. The fracture ends of specimens were mounted on aluminium stubs and sputter coated with a thin layer of gold to avoid electrostatic charging during examination.

**Result and Discussion**

Table 2 shows the effect of filler in corporation on tensile strength of uncompatibilized and compatibilized of LDPE/clay composites. The tensile strength of composites decreased with increasing filler loading. The reduction of tensile strength might be due to irregular shaped of fillers, their capability to support stress transmitted from the polymer matrix is rather poor. At the similar filler loading LDPE/clay composites treated with PEAA exhibit higher tensile strength compared to the similar composites but without PEAA.

The incorporation of clay into LDPE matrix has resulted in a dramatic reduction in the elongation at break (Table 2). The ductility of LDPE, as indicated by its high elongation at break. The decreased of elongation at break with increasing filler loading due to attributed to the decreased deformability of a rigid interface between the filler and the matrix. It can be seen also from Table 2, which compatibilized LDPE/clay composites exhibit lower elongation at break than uncompatibilized LDPE/clay composites. This indicates that the PEAA imparts a greater stiffening effect to clay filled LDPE composites.

The increase in Young's modulus with filler loading clearly indicates the ability of clay fillers to impart greater stiffness to the LDPE composites. At a similar filler loading, Young's modulus of the compatibilized LDPE/clay composites is higher than that of uncompatibilized LDPE/clay composites.

Table 2. Tensile properties of LDPE/clay composites for uncompatibilised and compatibilised with PEAA

| Filler loading (%) | Uncompatibilised composites | | | Compatibilised composites | | |
|---|---|---|---|---|---|---|
| | Tensile strength (MPa) | Elongation at break (%) | Young's modulus (Mpa) | Tensile strength (Mpa) | Elongation at break (%) | Young's modulus (Mpa) |
| 0 | 11.26 | 327 | 146 | 11.26 | 327 | 146 |
| 10 | 10.60 | 46 | 157 | 12.36 | 26 | 231 |
| 20 | 10.30 | 25 | 279 | 11.70 | 21 | 298 |
| 30 | 10.00 | 20 | 355 | 11.02 | 14 | 365 |
| 40 | 9.98 | 13 | 396 | 10.86 | 8 | 435 |

The scanning microscope electron (SEM) was used to examine the tensile fracture surface of LDPE/clay composite based on 20 wt% and 40 wt% of filler as shown in Figures 1 and 2. Figs. 1 and 2 show poor adhesion of the filler to matrix, as evident from the voids between the matrix and filler agglomerates. These voids act as stress concentration points and contribute to decrement of mechanical properties. Furthermore, as filler loading increases, the size of the clay agglomerates also increases. As the amount of filler loading increases, the tendency for filler-filler interactions increase, resulting in bigger filler agglomerates. This result in a higher level of dewetting of filler agglomerates by the matrix. The Figures also provide a good indication for the occurrence of particle filler pull out. Figures 3 and 4 show better adhesion occurred between clay and LDPE matrix where the traces of clay detachment from LDPE matrix are minimum. LDPE/clay composite with PEAA at 20 wt% and 40 wt% loading exhibit a smooth fractured surface with filler embedded in the matrix and fully covered by the matrix with no sign of air trapped in the composites, compared to LDPE/clay composite without PEAA (Figures 1 and 2). This indicates that PEAA improves the interfacial adhesion between matrix and filler, thus increasing the tensile strength of the composites.

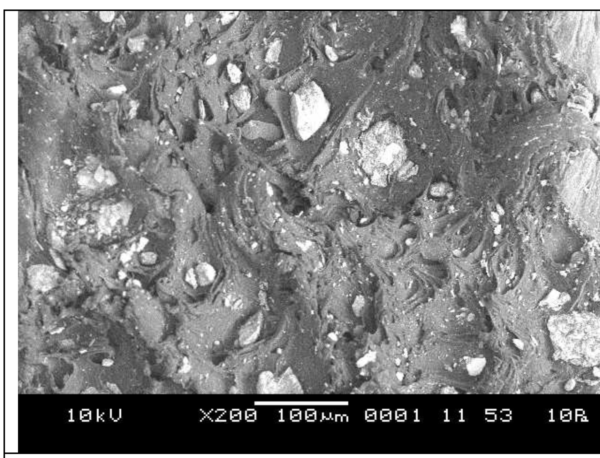


**Figure 1: SEM micrograph of LDPE/clay composites without PEAA (20 wt% filler loading) at magnification 200x.**

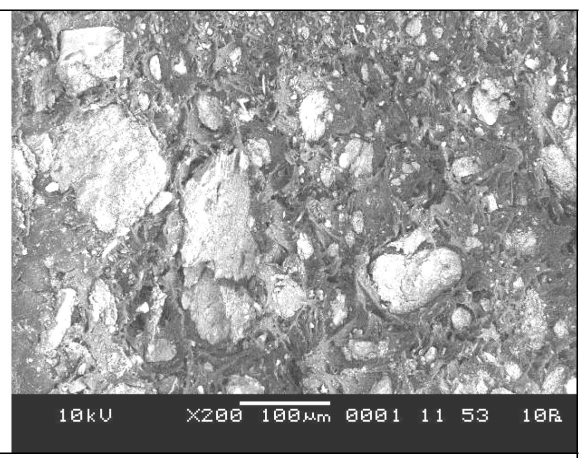


**Figure 2: SEM micrograph of LDPE/clay composites without PEAA (40 wt% filler loading) at magnification 200x.**

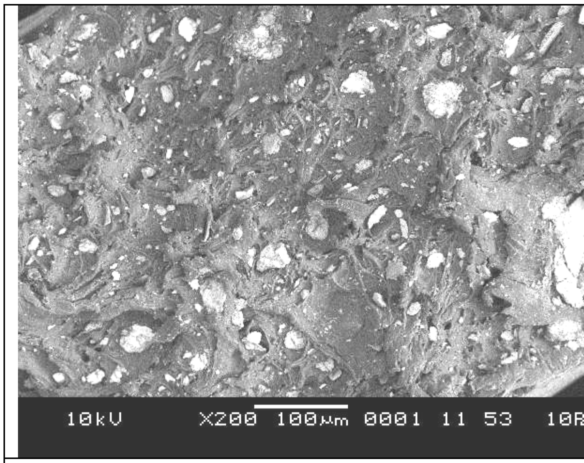


**Figure 3: SEM micrograph of LDPE/clay composites with PEAA (20 wt% filler loading) at magnification 200x.**

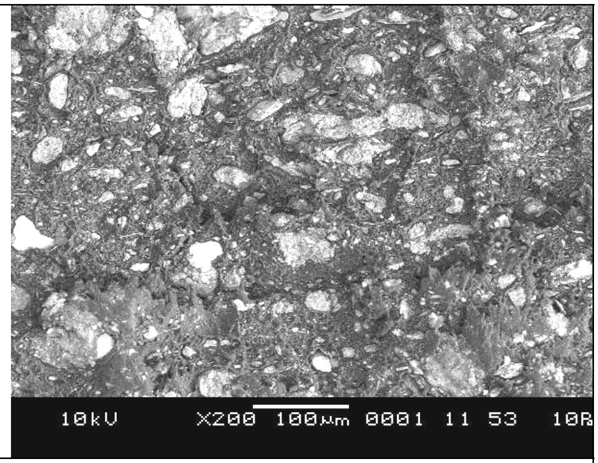


**Figure 4: SEM micrograph of LDPE/clay composites with PEAA (40 wt% filler loading) at magnification 200x.**

**Conclusion**

The presence of Polyethylene-Acrylic Acid (PEAA) increased the tensile strength and Young's modulus but decreased the elongation at break of LDPE/clay composites. Scanning electron microscopy (SEM) of tensile fracture surface of composite indicates that the PEAA improved the interfacial interaction between clay and LDPE matrix.

**References**


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