



## The Effect of Filler Content on Mechanical Properties of Polypropylene/Clay Nanocomposites

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### Abstract

This study investigated the effect of filler content on mechanical properties of polypropylene. There are synthesis clay and un-synthesis clay used as filler content. Different ratio of clay in polypropylene to study which ratio has a better mechanical property. The tensile test was carried out using INSTRON5565 and the maximum stress, strain, and modulus of elasticity observed. The experimental results showed that polypropylene/clay nanocomposite has a higher maximum stress compare to pure polypropylene and un-synthesis clay. Besides that modulus of elasticity of specimen calculated and finds that it increased with increment filler content and strain did not affect by filler. The synthesis clay filled into polypropylene will have a better mechanical property.

*Keywords:* nanocomposite, polypropylene, synthesis clay

### 1. Introduction

The modern technology knows that required for unusual combination of the properties which cannot find by using conventional metal alloys, ceramics, and polymeric materials. This is true especially for materials that needed for aerospace, underwater, and transportation applications (Kawasumi *et al.*, 1997).

The combinations of properties and range have been, and are yet being, extended by the development of the composites materials. Generally a composite material is considered to be any multiphase material that exhibits a significant proportion of the properties of both constituent phases such that a better combination was fashion by judicious which combine of two or more distinct material. The most widely that using ceramic raw materials is clay (Treece and Oberhauser, 2007). This is in-expensive ingredient, the found of naturally in great abundance, and often used as mined without any upgrading of the quality. Nano-size is montmorillonite clay dispersed in small amounts in polymer results in polymer nanocomposites in that have superior of engineering properties compared by native polymer. This inclusion was created by treat the clay with an organic modifier which makes clay organophilic material. This result is in intercalation or exfoliation of the montmorillonite (Chiu and Chu, 2006).

Meanwhile, polypropylene (PP) have high melting point relatively, that make useful for

plastic. The PP properties were determined by its crystalline structure. The relative is depends on amount of amorphous and crystalline phases, crystal modification, size and perfection of crystallites, dimensions of spherulites and the number of the tie of molecules which all give the effect of performance for PP products. It seems to be certain that the increasing of crystalline and spherulites size will make the modulus of the PP increases, and the strength and its deformability will decrease (Maiti *et al.*, 2002; Marchant and Jayaraman, 2002).

The purpose of this research is to investigate and compare the mechanical properties of Polypropylene/clay nanocomposites with the pure material. The specification is to conduct and investigate the effect of the filler content on mechanical properties of polypropylene/clay nanocomposite and differences mechanical between polypropylene/clay nanocomposites with the pure clay and pure PP.

### 2. Methodology

#### 2.1 Materials

The material used can be divided into two types, the matrix materials (PP) and the reinforce material is clay. The PP used was purchased from the Titan1Co. It is a Na<sup>+</sup> type montmorillonite, with a cation exchange capacity of 119 meq/100 g. Other inorganic and organic materials that were used in this

study were obtained from commercially available sources.

## 2.2 Preparation of Pristine Clay to Clay Nanocomposites

An amount of 0.05 mole (18.223 g) CTAB with 200 ml distilled water as solution A. Solution A heated at 80°C and stirred with magnetic stirrer for 1 hour or more. A twenty gram of KUNIPIA-F was added with 600 ml distilled water as solution B. Solution B was heated and stirred at 80°C for 1 hour or above. After heating and stirring process, solution A was mixed into solution B. The mixture was added with distilled water until the volume reached 1000 ml. Then it heated and stirred at 80°C for 1 hour. 0.1 mole (1.6988 g) AgNO<sub>3</sub> was added with 100ml distilled water by using volumetric flask and then kept in refrigerator. The function of solution for AgNO<sub>3</sub> is become tester to ensure that do not have chloride in the clay that produce. The mixture filtrated with using Aspirator until it do not change to dark color when test with AgNO<sub>3</sub> solution. If it still changes the color, mix the solid with hot distilled water and filtrate again. The procedure is repeated for three times to get more clay. The clay was dried in the microwave at 100°C for 3 days. After the clay was dried, it was grilled to let it became smaller size and sieved by using 125 µm sieve tray (Tang *et al.*, 2005).

## 2.3 Molding of Specimens

The Thermo Haake Polydrive was used to blend the materials. Melt blending was carried out at 175°C and rotor speed was set to 100 rpm. The weighted clay was added into the mixing chamber when polypropylene was melted. The mixing was stopped after the preset during duration of 10 minutes. Lastly, the specimen was removed from the mixing chamber and the rotors were cleaned after each cycle of specimens molding. The steps were repeated for prepare several specimens according to the ratio of polypropylene and clay nanocomposite or with pristine clay. Each specimen was in 40 g (Quintanilla *et al.*, 2006).

## 2.4 Molding of Specimen in Square Plate

The hot and cold laboratory presses was used in the preparation of 1 mm thick square plate. It was carried out at 175°C under the

pressure 150 kh/cm<sup>2</sup> for 2 minutes of pre-heating and 5 minutes of full pressing cycle. The sheets were immediately cooled between two plates of cold pressed at 25°C for 5 minutes of cooling cycle.

## 2.5 Testing the Specimens

Tensile test were carried out by using INSTRON 5565 Universal Testing Machine, using a load cell of 5kN. The crosshead speed was set to 1.0 mm/minutes. The thickness set to 0.88 mm, width 3.51 mm and length to 26.09 mm.

## 3. Results and Discussion

### 3.1 Result

#### Pure Polypropylene

The result of the tensile test for pure polypropylene was depicted in Fig. 1. The curve those shown in figure were almost same. It was within 13.2975 MPa to 15.5010 MPa. The average of the maximum stress was 14.6806 MPa and the strain was 0.04 mm/mm. Modulus of elasticity was about 772.02 MPa

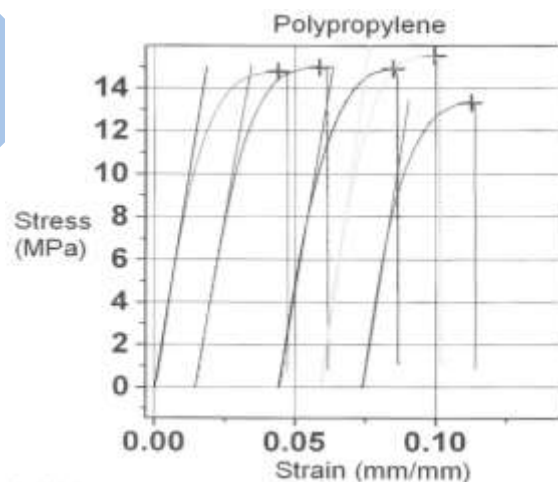
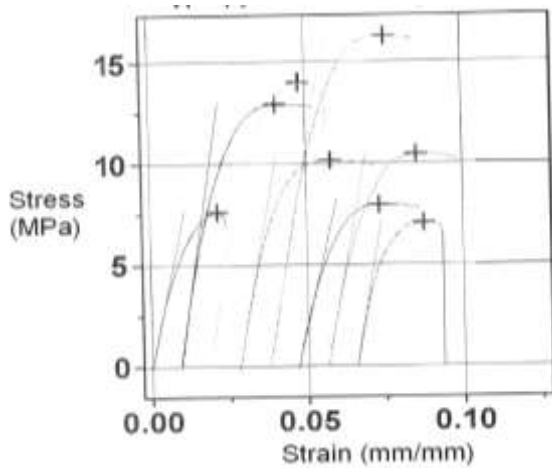


Figure 1. Result for pure polypropylene.

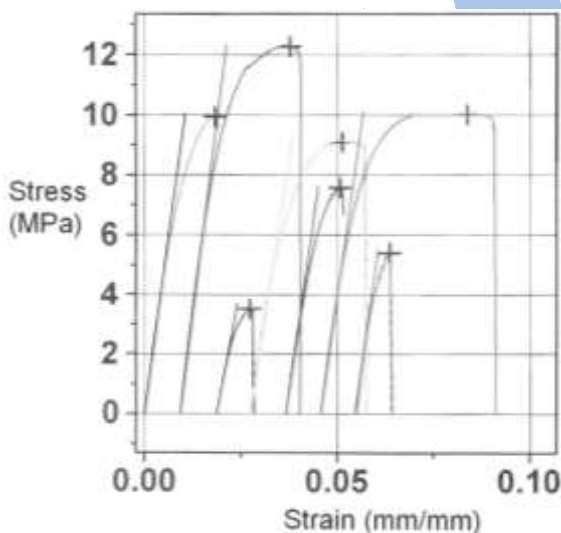
#### Polypropylene 99% / Unsynthesis Clay 1%

The curve of the tensile test for the ratio was performed in Fig. 2. The maximum stress was within 7.0614 MPa to 16.2566 MPa and the distance between them was smaller compared with two types of ratio specimen above. The average of the maximum stress

was 10.8012 MPa and the strain was 0.03 mm/mm. Modulus of elasticity is 852.7025 MPa.



**Figure 2.** Result for polypropylene 99%/ unsynthesis clay 1%.



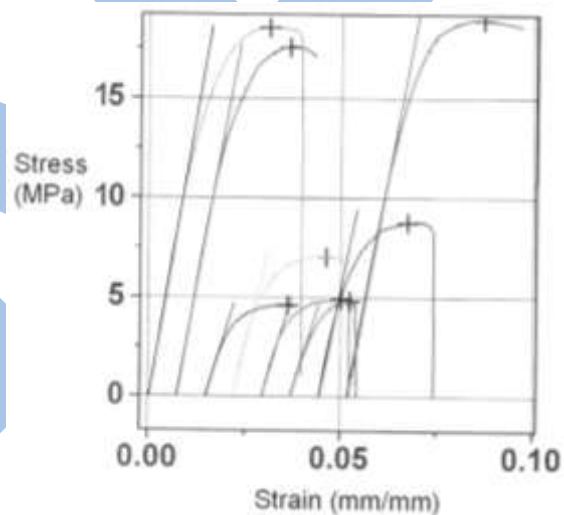
**Figure 3.** Result for polypropylene 97%/ unsynthesis clay 3%.

### **Polypropylene 97% / Unsynthesis Clay 3%**

The curve of the tensile that performed was depicted in Fig. 3. The process that happens on the specimen was same for the tensile test of other difference ration specimens. Its also have very uncertain height of curve. It was within 3.5267 MPa to 12.2626 Mpa and the distance between them was big. The average of the maximum stress was 8.2390 MPa and the strain was 0.02 mm/mm. Modulus of elasticity was about 885.76 MPa.

### **Polypropylene 95% / Unsynthesis Clay 5%**

The curve of the tensile test that performed was depicted in Fig. 4. It can found that there have two regions. The first part was in straight line that is in elastic region. As the load increases, the strain will increase proportional with stress and when it reaches one point, the line will slowly curved. That means it entering plastic region and it will experience yielding, strain hardening and last necking then the specimen will fracture. From the curve it was clearly shown that it has an uncertain maximum stress. Some of the curve was very high and some was very low. It was within 4.6134 MPa to 18.9044 MPa and the distance between them was big. The average of the maximum stress was 10.6460 MPa and the strain was 0.03 mm/mm. Modulus of elasticity was about 909.6025 MPa.



**Figure 4.** Result for polypropylene 95%/ unsynthesis clay 5%.

### **Polypropylene 99% / Synthesis Clay 1%**

The result of the tensile for the ratio of specimen was depicted in Fig. 5. A difference for the heights of curve was not very big. It was within 14.3940 MPa to 18.6192 MPa. The average of the maximum stress was 16.8377 MPa and the strain was 0.03 mm/mm. From the experiment, it was found that the modulus of elasticity was about 1114.86 MPa.

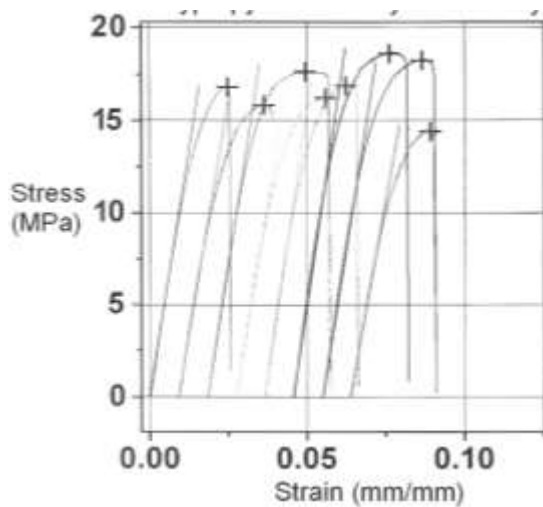
### **Polypropylene 97% / Synthesis Clay 3%**

Fig. 6 was present the curve for the ratio of this experiments. The curves of this test have similar heights which mean there have almost same maximum of stress. The value

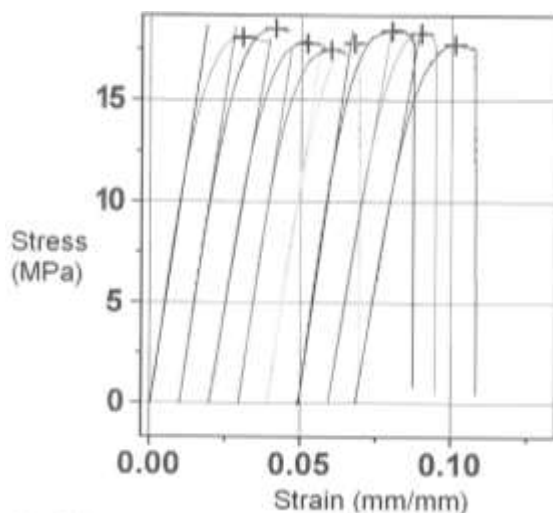
of stress was within 17.4820 MPa to 18.5544 MPa. The average of the maximum stress was 18.0407 MPa and the strain was 0.03 mm/mm. Modulus of elasticity was about 1117.63 MPa.

### **Polypropylene 95% / Synthesis Clay 5%**

The curve of the tensile test that performed was depicted in Fig. 7. The curve in this test has a quite balance height. It was within 12.2074 MPa to 17.8714 MPa. The average of the maximum stress was 16.8576 MPa and the strain was 0.03mm/mm. It was also observed that the modulus of elasticity was about 1858.255 MPa.



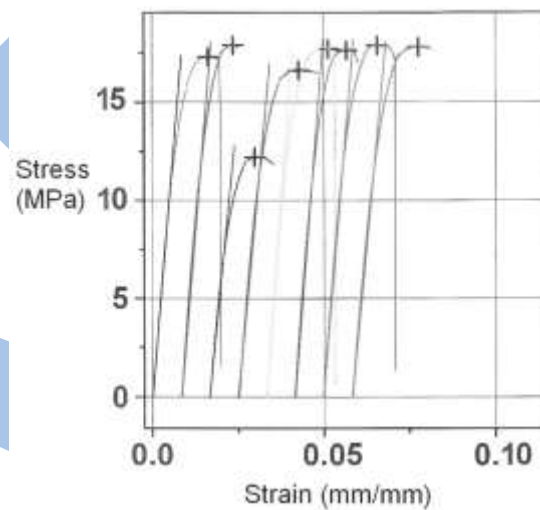
**Figure 5.** Result for polypropylene 99%/ synthesis clay 1%.



**Figure 6.** Result for polypropylene 97%/ synthesis clay 1%.

### **3.2 Discussion**

As found from the results in the previous section, it was clearly stated that the Polypropylene filled with synthesis clay was have the higher tensile of strength and modulus of elasticity compared from each other. The pure polypropylene and polypropylene with synthesis clay as filler having more steady maximum stress compare to the unsynthesis clay as filler. It was because the bonding between the molecules constituted of the material (Bureau *et al.*, 2006).



**Figure 7.** Result for polypropylene 95%/ synthesis clay 5%.

Pure clay that is unsynthesis clay was hydrophilic (e.g. water) and polypropylene was hydrophobic (dislike water). They have different in their properties so when both of them mixed will not having of good bonding between them. The unsynthesis clay will disturb the bonding inside the polypropylene and it will reduce the maximum stress of the polypropylene. It was explained by the tensile test that performed. Their have three ratio of mixing between unsynthesis clay with polypropylene, that is 1%, 3%, 5% of unsynthesis clay. In these three ratios, for the 3% unsynthesis have the lowest stress and follow by 5% and 1%. Frounchi *et al.* (2006) was also reported a same result trend.

After the clay been synthesis, it becomes same properties with polypropylene that was hydrophobic. The synthesis will open the layer of the clay that the polypropylene will lay between the layers at the blending process. When have the same behavior, it

will make them bonding more strong. As found at the results of the experiment, the polypropylene filled with synthesis clay having a higher maximum stress. It means it can stand for larger load compare to pure polypropylene or filled with unsynthesis clay the modulus of elasticity was increased according to the increasing in the maximum load. In three of the ratio mixing synthesis clay, the 3% have a highest maximum stress then follow up by 5% and 1%. It was because when having so much filler, it will make it slowing weakening of the bonding between polymer and filler. So, from this experiment it was shown that 3% synthesis clay was having better tensile strength than that it will reduce the tensile strength. It was proved when maximum stress of 5% was less than 3% (Yuan and Misra, 2006).

The strain for the entire specimen was almost same. So, the strain of material did not affected by the filler. In the curve for tensile test, there have elastic and plastic regions. When observed from Fig. 1-7, we can found that the plastic region is larger than elastic region. As shown by the straight line that drawn, the elastic region was at the straight line and the curve line was plastic region. After calculated the modulus of elasticity limit, fillers will increase the modulus of elasticity for the material. As the amounts of the filler will increase, the modulus of elasticity will increase also. The synthesis clay will have the higher of the modulus of elasticity compared to the unsynthesis clay as filler. The same experimental results were also reported by Benetti *et al.*, 2005.

#### 4. Conclusion

Polypropylene / clay nanocomposites were fabricated and tensile test was carried out for this survey. The effect of clay filled on mechanical properties such as maximum stress, strain and modulus of elasticity, for polypropylene has been observed in this work. The following conclusion can be made regarding this research, i.e.: the polypropylene/synthesis clay has a highest maximum strength then followed up by pure polypropylene and polypropylene/unsynthesis clay was lowest; the modulus of elasticity increased with increased of filler content; and synthesis clay as filler has a higher modulus of elasticity. Also, it can be concluded that the filler content did not affect the strain of the nanocomposites.

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