TENSILE PROPERTIES OF GROUND COLEMANITE FILLED POLYPROPYLENE HOMOPOLYMER

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ABSTRACT: In this study the effect of the ground colemanite (GC) substance, to the tensile properties of the polypropylene homopolymer (PPH) material, was studied. The average particle size (d0.5) of the GC substance was 20.6 μm. The PPH raw material was filled with GC at different percentage rates (5, 7.5, 10, 12.5, 15, 17.5, 20, 22.5, 25, 27.5 and 30%) by weight with a twin-screw extrusion machine by constant extrusion parameters. Firstly, the melt flow rates (MFR) of the filled (PPH/GC composite) and unfilled (pure PPH) raw materials were determined. Secondly, the pure and the composite raw materials were pressed into standard tensile specimens with an injection-moulding machine by constant injection parameters. The test experiments were performed with samples at constant experiment conditions. The results were given according to the increasing amount of GC filler content in PPH base material. It was detected that, GC substance increases the MFR, Young's modulus and tensile strength at break, while it decreases the tensile strength at yield, the tensile strain at yield and at break of the material.

Keywords: Polypropylene homopolymer, Ground colemanite, Composite, Tensile Properties, Melt flow rate

1. INTRODUCTION

For small or big, kitchen or bathroom, electrical or electronic household appliances and in computer technology, polypropylene (PP) is a frequently used material [Bentham, 1999]. During the production of goods with PP raw material by using several methods, before only in order to reduce the cost of the product [Osman, 2004] however nowadays to improve the mechanical, thermal and electrical properties, some kind of filling materials are added while forming operation is done [Kwon, 2002]. Within this scope, especially PPH materials, with micro particle filling substance such as talc, calcium carbonate and as a reinforcement substance glass fiber, are preferred because of their high rigidity and good thermal performances. Another reason of their preferability is the high price-volume-performance relation of this material, compared to commonly used other materials [Pukánszky, 1995]. The semi-crystalline thermoplastics and the applications that filled with various micro particles of these have been subjected to numerous studies. Many researches accomplished to understand the deformation characteristics of these thermoplastic materials [Zhou and Mallick, 2002]. It is a common opinion that, in composites with micro particles, particle size, adhesion between surfaces [Wulin *et al.*, 2000] and surface characteristics influence the performance of filled system substantially. Besides, it is known that particle shape, particle distribution and filler amount rate have a significant influence on system performance [Wah *et al.*, 2000].

However there isn't observed any kind of scientific studies for the tensile properties of GC filled PPH materials. Because of that reason the purpose of this study is to determine the change on rigidity and toughness values of GC filled PPH

composite materials depending on their filler amount ratio.

2. EXPERIMENTAL

2.1 Materials

In this study, the PPH has been used, which commercial name is MOPLEN HP500N (Basell Service Company B.V.) and values with 900 kg/m^3 density and 12 g/10 min (230°C/2.16 kg) MFR. The other values of PPH from the manufacturer is 1450 MPa modulus of flexural, 33 MPa, tensile strength at yield and 10% tensile elongation at yield about some mechanical properties for injection molding applications, according to ASTM D standard.

As the additive and/or filling substance, the mineral with the commercial name GC (Eti Mine Works General Management) was used. Some of the main properties of GC substance, which is obtained from mine site in Turkey-Bigadiç, given in Table 1, 2 and 3.

Table 1: Chemical specification.

Component	Unit	Content
B_2O_3	%	40.00±0.50
CaO	%	27.00±1.00
SiO_2	%	6.50 Max

Table 2: Sieve specification.

Particle Size	Unit	Content
+ 600 µm	%	0.02 Max.
+ 250 µm	%	0.50 Max.
- 75 µm	%	87.00±5.00
- 45 µm	%	75.00±5.00
Moisture	%	1.00 Max.
Bulk Density	g/cm^3	0.80-1.00

In the Table 4, features of the K5 PEW (is product name) - Empolim PE Wax (is brand name) (Zirve Polimer San. Tic. Ltd. Şti.) which is used as lubricant, are given. This lubricant substance is added 0.5% by weight rate to pure PPH material, during the production with different weight amount rates of GC filling materials.

Table 3: Particle size analysis results.

Specification	Unit	Typical
Average diameter (d0.5)	µm	20.596
TopCut (d0.9)	µm	66.559
Specific Surface Area	m^2/g	1.04

Table 4: Technical properties.

Specification	Unit	Typical Value
Structure		Less molecular polymer. ($n_{av.}$=700)
Appearance		White color flake or dust
Melting point	°C	95± 10
Bulk density	kg/m^3	500 ± 20
Acid Index		0
Soap Index		0
Purity	%	95 ± 5

2.2. Composite Preparation

For the PPH/GC composite raw materials production, twin-screw extruder (Coperion Werner and Pleiderer ZSK 25 P8.2 E WLE) has been used that has (L/D) 45 mm screw length and (L) 1125 mm helix length. Firstly, the lubricant substance PEWAX is added 0.5% by weight to pure PPH raw material in plastic raw material mixer. Later, the GC filled PPH composite raw materials were produced in different weight amount rates (5, 7.5, 10, 12.5, 15, 17.5, 20, 22.5, 25, 27.5 and 30 %) with the physical modification method. The production has been performed in extrusion of fixed parameters under the conditions of 900 rpm rotation speed, 30 kg/h production capacity, between 220°C and 245°C zone temperatures and 30°C cooling water bath

temperature. Each composite raw material has been performed dried at 50°C for 4 hours.

2.3. Sample Preparation

Pure PPH and PPH/GC composite raw materials was injection molded according to ISO 527-2 Type-1A tensile test samples which have dimensions as 216 mm x 10 mm x 4 mm by an injection machine (Haitian Plastics Machinery HTF 90W) with 46 mm screw diameter (D) and 20 screw length (L/D). In molding process done by considering ISO 294-1 standard, injection parameters which are fixed 235°C as nozzle temperature, 230°C/225°C/220°C as zone temperature, 1400 bars as injection pressure, 700 bars as holding pressure, 60 seconds as waiting time and 30°C as die cooling water temperature used. Test samples were conditioned before tests according to ISO 291.

2.4. Melt Flow Rate Test

Melt flow rate (MFR) experiments are done according to ISO 1133 standard, with the 4106 E Model of the Zwick-Roell brand test device. Experiments are done on granule of pure PPH and PPH/GC composite raw materials. For MFR tests to calculate the sample weight, 4.4 times of density was calculated and precisely weighed before tests. The experiments were performed at 230°C test temperature with 2.16 kg test load. The values taken from the device with g/10 min unit are taken as MFR results.

2.5. Tensile Test

The tensile tests were done by considering ISO 527-1 with a tensile test machine (INSTRON 4411 H 4240) which has a capacity of 5 kN with Bluehill-2 software (ver. 2.6) and Clip - on static extensometer (INSTRON 2630-111) on it. According to ISO 527-2 standard, 216 mm x 10 mm x 4 mm sized Type-1A tensile samples were placed in the tensile test machine, so that injection entrance is on the fixed grip of the tensile test machine.

The tests were done under 22°C±1°C temperature and 50%±10% humidity. For each value at least 5 test specimens were used. Obtained values were statistically considered according to Chauvenet Criteria [Holman, 1994].

3. RESULT AND DISCUSSION

It is important to mention that pure PPH raw material is used without the exposition of twin-screw extruder parameters as it is in PPH/GC composite raw materials. Also during the study pure PPH raw material was used without addition of PEW.

In Figure 1 change on MFR of pure PPH material according to increasing addition of GC filling material amount is shown. In the graphic, it is seen that addition of 5 wt% GC increases 35% MFR value of pure PPH material. On the other hand, it is determined that addition of more than 5wt% GC, decreased the MFR value of PPH/GC composite materials. Even though it is discovered also that 30 wt% GC filled PPH/GC composite materials, had 10% higher MFR value, compared to pure PPH material.

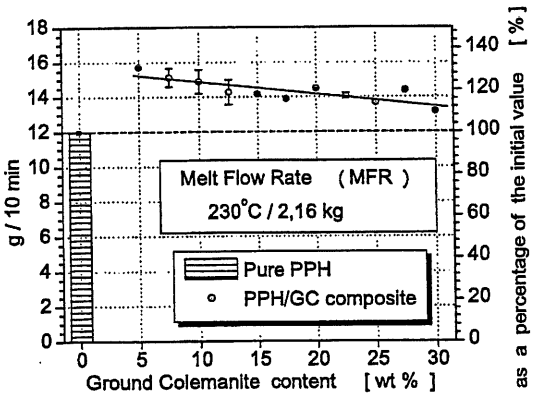

Figure 1: The change of the melt flow rate of PPH material.

Figure 2 shows the affect on Young's Modulus (E) with increasing amount of GC in pure PPH materials. From the figure it is possible to see that 5 wt% of GC increases Young's Modulus around 3%. Addition of GC material more than 5wt% to PPH/GC composite material, increased E value much more. At the end it is found that 30wt% of GC filling material have approximately 45% increases E value than pure PPH material.

In Figure 3, change on the maximum tensile stress (σ_M) depending on increasing amount of GC filling material is shown. It is seen that 5 wt% GC decreased the maximum tensile stress of pure PPH material around 9%. On the other hand, increase of GC amount more than 5 wt%, decreases the maximum tensile stress of PPH/GC composite much more. It is seen that 30wt% GC filled PPH/GC composite materials have around 32% lower maximum tensile stress than pure PPH materials.

In Figure 4, change on maximum tensile strain (ε_M) value of pure PPH material with the increase of GC filling material is given. By the figure it can be seen that 5wt% GC decreases the maximum tensile strain of pure PPH material around 14%. Addition of GC amount higher than 5wt% causes much more wane on the maximum tensile strain of PPH/GC composite materials. It is too seen that 30wt% GC filled PPH/GC composite material have around 50% lower maximum tensile strain value than pure PPH materials.

Figure 5 shows us change on tensile break stress (σ_B) value of pure PPH material with the addition of GC filling material. It is determined that 5wt% GC in pure PPH material increase the tensile break stress about 23%. PPH/GC composite materials containing GC substance amount higher than 5wt% had lower tensile break stresses. However, tensile break stress of PPH/GC composites including 25 wt% GC had almost the same value with pure PPH material. In addition to this PPH-GC composite materials filled with 30wt% of GC had tensile break Stress only 4% lower than the pure material.

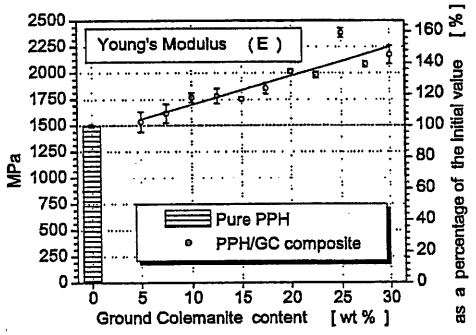

Figure 2: The change of the Young's modulus of PPH material.

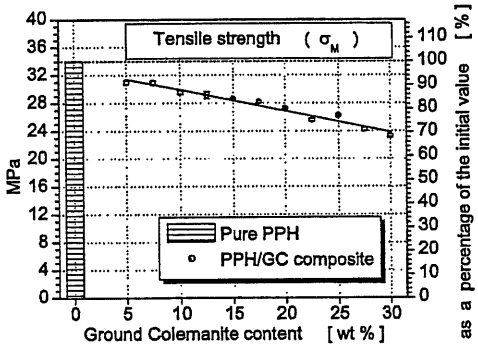

Figure 3: The change of the stress at yield of PPH material.

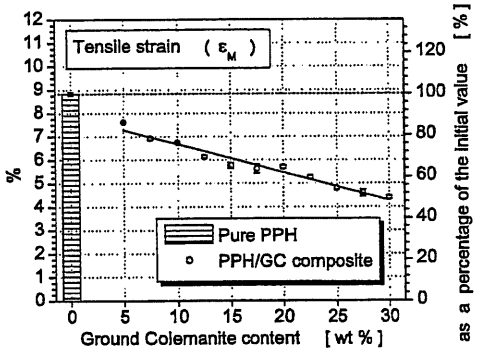

Figure 4: The change of the strain at yield of PPH material.

In Figure 6, changes on tensile break strain (ε_B) value with addition of GC filling material into pure PPH material is given. From the figure it is seen that amount of 5 wt% GC in pure PPH material reduces suddenly the Tensile Break Strain around 94%. Addition of more than 5 wt% GC filling material also lowered much more the tensile break strain.

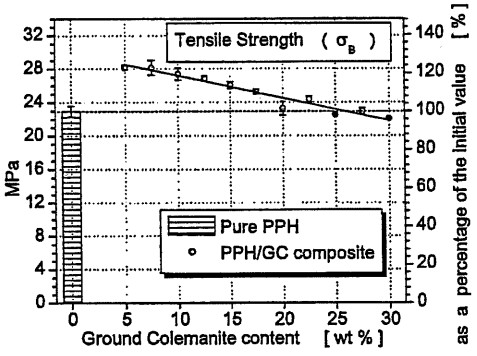

Figure 5: The change of the stress at break of PPH material.

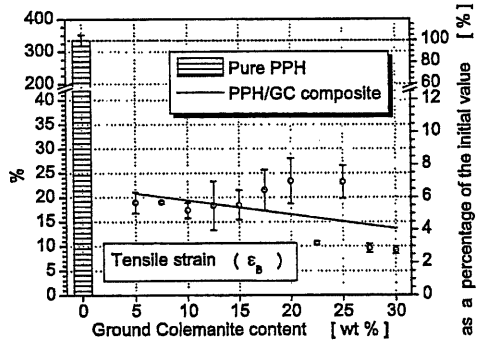

Figure 6: The change of the strain at break of PPH material.

4. CONCLUSIONS

It is discovered that each tensile characteristics of pure PPH material is influenced by the addition of 5wt% GC filling material. In experiments, increase on the values of Young's Modulus with 3% and tensile break stress with 23% is seen. However decrease on maximum tensile stress with 9%, maximum tensile strain with 14% and tensile break strain with 94% is determined. It is also seen that tensile characteristics of PPH-GC composite materials are affected from increasing amount of GC filling material. Increasing GC filling material amount rose Young's Modulus of PPH/GC composites but decreased Maximum tensile stress, tensile break Stress, Maximum tensile Strain and Tensile Break Strain. But even if the increasing GC filling material amount caused decrease on tensile break stress, it is also seen that PPH/GC composite material with 25wt% GC filling material had approximately the same value with pure PPH material.

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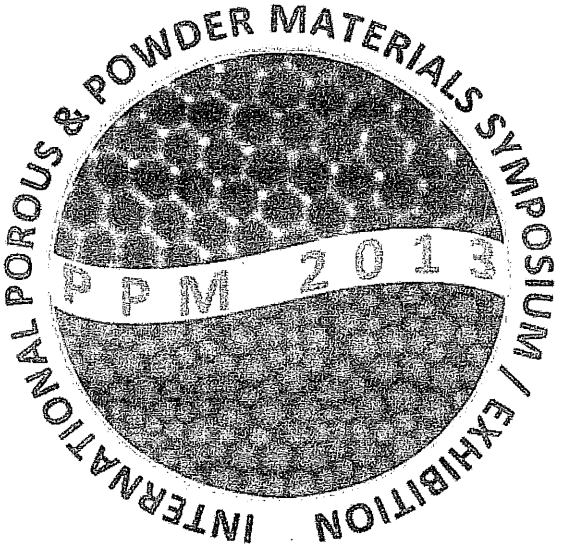

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