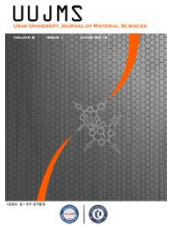
Usak University Journal of Material Sciences
journal homepage: http://uujms.usak.edu.tr



Research article

An investigation on physical properties of polyethylene composite with bentonite, kaolin and calcium carbonate additives

Sencer S. Karabeyoğlu, Nurşen Öntürk*

Mechanical Engineering Department, Engineering Faculty, Namık Kemal University, Turkey

Received 27 December 2013 *Revised 24 February 2014* *Accepted 24 June 2014*

Abstract

Bentonite, Kaolin, Calcium carbonate easily obtained in nature as mineral products are widely used in plastics industry for additive materials. In this study, Bentonite, Kaolin, and Calcium carbonate minerals were compounded with polyethylene matrix used in specific rates. Prepared compounds melted in sheet metal molds and cooled down under appropriate conditions. Thus, production of composite material was achieved. Hardness, water absorption, and physical properties of manufactured composite test specimens were investigated accurately.

Keywords: *Polyethylene, bentonite, kaolin, density, hardness, water absorption*

1. Introduction

Polyethylene (PE), which is one of the most used materials in plastic industry, comes forward because of its property of availability. Plastic films, bottles, a large number of packages are made of PE that is known to be used commonly. Its cost may be taken into account as an advantage when compared to other polymer materials [1-3]. This material is separated into two different grades by density. These are low density PE and high density PE [4]. Clay contributions are used commonly as an additive in polymer materials. The most using one is kaolin, wallastonit, calcium carbonate, and bentonite. Adding reinforcement or an additive to an unreinforced polymer matrix material changes the mechanical and physical properties of composite [5,6]. Kaolin clay, which is production of Feldspat, is very important in terms of mechanical and thermal properties. In addition, this material which is used as dyestuff additive is widely used in paper industry [7]. Bentonite clay comes into prominence with moisture absorbency and capability to expand its volume 8-10 times compared to its original volume. This material, which has a lot of usage area from water well drying proses in the geological studies to the production of cat sand is used with plastic materials so that mechanical and physical properties increased [8,9]. Calcium carbonate is used frequently in plastic sector. This material which is used to increase colour property and quality of dyeing is often seem in nature [10,11]. In this study, calcium carbonate, bentonite, and kaolin clay were

*Corresponding author:
E-mail: skarabeyoglu@nku.edu.tr
DOI: 10.12748/uujms.201416500

mixed with Low Density Polyethylene (LDPE) material in certain mass ratio, and composite materials are made. The relation between hardness, moisture absorbency, mixed ratio of density of composite materials which were made examined.

2. Material and Method

In this study, PETKİM Company's material called LDPE which commercial name is PETİLEN G03-5, was used. The properties of material PETİLEN G03-5 which is widely using in wire/pipe extrusion and inflation process; density of materials at 23 ^{o}C is 0.919-0.923 g/cm^3 , hardness of material is 47 Shore D, tensile stress in yield point is 95 kg/cm^2 , tensile stress in break point is 190 kg/cm^2. The properties of material of nanotonite bp 183 bentonite clay; density of material is 1.7 gr/cm^3, moisture of material is below 3.5%, colour of material is white and applying mesh over 98% (fineness with 200 mesh). The properties of bentonite clay, called nanotonite bp 183, and calcium carbonate, called Nano Carb-2X commercially, are given in Table 1 and Table 2, respectively.

Table 1
The properties of material of UR-C 70/90 kaolin

Physical Properties		**Chemical Properties**	
Brightness (ISO)	90±1	SiO_2 (%)	48.7
Residue (325#)	Max 0.01	Al_2O_3 (%)	47.4
>5 micron (%)	6	Fe_2O_3 (%)	0.6
<2 micron (%)	68-72	TiO_2 (%)	0.6
Moisture (%)	Max 1%	Alkalines (%)	0.4
pH	5.5-6.5	Mineral (%)	<0.1
specific weight	2.64	Generally Amorf	

Table 2
The properties of material of Nano Carb-2X Calcium carbonate

Physical Properties		**Chemical Properties**	
Density (g/cm^3)	2.70	$CaCO_3$ (%)	> 99
Hardness (mohs)	3	$MgCO_3$ (%)	< 0.2
Refractive index	1.57	Fe_2O_3 (%)	< 0.1
Brightness	96	SiO_2 (%)	< 0.1
pH	9	Al_2O_3 (%)	< 0.2
Density (g/cm^3)	1.15	Unsolved in HCL (%)	< 0.1

Sheet molding is used to make composite material with 4 mm thickness, 18.45 mm depth, 120 mm width, and 145 mm length. Sheet molding is covered with aluminium foil to prevent clinging of samples. The mold used in this study is shown in Fig. 1.

Fig. 1 The die which is used for creating test samples

To create samples, LDPE, bentonite, kaolin, and calcium carbonate clays in certain mass and same duration mixed in the lock bags. The mixed ratio of experiment samples is illustrated in Table 3. The mixed materials are put in to die properly is shown in Fig. 2.

Table 3
The mixed ratio and name of experiment samples

Mixtures	**Name**	**AYPE (%)**	**Bentonite (%)**	**Kaolin (%)**	**Calcium Carbonat** (%)
Mixture 1	PECB	93	3.50	-	3.50
Mixture 2	PEKB	93	-	3.50	3.50
Mixture 3	PECK	93	3.50	3.50	-

The prepared mold is melted in furnace which is set 200-220°C mold temperature. The mixtures which create experiment samples are waited in furnace for 40 min. Before extracting from the mold, material compressed under 0.1 bar pressure in hydraulic press for 20 min. To extract the sample sheet from the mold, waiting for the mold temperature decrease to 25°C. Experimental samples are shown in Fig. 3.

Fig. 2 An illustration of molded samples

Fig. 3 The produced experimental samples

3. Results and Discussions

The densities of experimental samples created, which are made according to TS EN ISO 1183-1, are shown in Table 4. Hardness of samples, which are made 5 times in both sizes and appropriate to TS 1181 EN ISO 868 standards, are shown in Table 5. The moisture absorbencies of samples, which are made appropriate to ISO 62 standards, are shown Table 6.

Table 4
The densities of experimental results

Made test	Unit	PECB	PECK	PEKB
Density	g/cm^3	0.932	0.936	0.931
Distribution (min/max)		0.930/0.933	0.936/0.937	0.9305/0.9306

Table 5
The hardness of experimental results

Made Test	Unit	PECB	PECK	PEKB
Hardness	Shore D	49	51	50
Distrubution(min/max.)		46/51	48/52	47/52

Table 6
The moisture absorbencies of experimental results

Experiment samples	PECB	PECK	PEKB
Moisture absorbency (%)	0.74	0.82	0.99

As a result of density test, it has been found that density of PECK of composite material is the maximum value according to material of PECB and PEKB. It has been determined as a result of Bentonite; has low surface density compared to other clays. It has been found by the hardness experiment. According to results of made on samples, from 10 different regions, surface hardness value of PECK composite is max. It has been concluded that the morphological result of kaolin material increases the hardness value of the composite material. When result of samples, which is exposed water absorption, analysed, it has been found that PEKB composite has the most moisture absorbency compared to other two samples. This phenomenon is because of superior moisture absorbency of kaolin and bentonite.

4. Conclusion

Composite materials were produced by mixing polymer matrix and clay combinations which have different physical properties. Clay mixtures which were prepared as binary combinations were added into composite material as 3.5% by weight. As results of hardness, density and moisture absorption tests, morphological and physical properties of kaolin and bentonite materials reveal better results than the other mixtures on moisture absorption and density. Higher moisture absorbency of bentonite material and stable hardness values of kaolin with moisture variation has provided to produce best mixture ratios.

References

1. Takeda Y. Crystallization and elongation of irradiated high-density polyethylene. Radiation Physics and Chemistry, 1981; 18(5-6): 853 – 858.
2. Cengiz İ. Thermodynamic analysis of polyethylene and polypropylene based products and plastic injection molding process parameters with heat dissipation methods, MSc Thesis, Kastamonu University, Turkey, 2012.
3. Akkurt S. Plastik Malzeme Bilgisi, Birsen Yayınevi, 1981:7, İstanbul.
4. Schaffer JP, Saxena A, Antolovich D, Sanders TH, and Warner SB. The Science and Design of Engineering Materials, 2nd edition, Mc Graw-Hill, 1999:194, Singapore.
5. D'yachkovskii FS and Lyudmila A Novokshonova. The synthesis and properties of polymerisation-filled polyalkenes, Russian Chemical Journals 1984; 53: 117 – 131.
6. Arroyo M, Suárez RV, Herrero B and López-Manchado MA. Optimisation of nanocomposites based on polypropylene/polyethylene blends and organo-bentonite, 2003; 13: 2915 – 2921.
7. Murray HH and Kogel JE. Engineered clay products for the paper industry. Applied Clay Science, 2005; 29(3-4): 199 – 206.
8. Murray HH: Overview-clay mineral applications. Applied Clay Science, 1991; 5(5-6): 379 – 395.
9. Murray HH. Traditional and new applications for kaolin, smectite, and palygorskite: a general overview. Applied Clay Science, 2000; 17(5-6): 207 – 221.
10. Tjong SC, Li RKY, and Cheung T. Mechanical behavior of $CaCO_3$ particulate-filled β-crystalline phase polypropylene composites. Polymer Engineering & Science, 1997; 37(1): 166 – 172.
11. Ling Z, Zhenghua W, Rui H, Liangbin L, and Xinyuan Z. PP/elastomer/calcium carbonate composites: effect of elastomer and calcium carbonate contents on the deformation and impact behavior. Journal of Material Science, 2002; 37(13): 2615 – 2621.