Improvement of Locally Produced Low- Density Polyethylene

Dr.Najat .J.saleh **Zanaib.Y.shnean***

Received on:10/9/2007
Accepted on: 3/2/2008

Abstract

In the present work, a polymer composite was fabricated by mixing LDPE with different wt% of pigment (Fe_2O_3 and TiO_2) to obtain desirable properties in fabrication single screw-extruder was utilized , this mixing machine operated at a temperature between (150-170)C^o.some of mechanical properties, such as tensile, impact, hardness and bending test were determined at different weight fraction of composite materials. It was found that the addition of pigment (TiO_2 and Fe_2O_3) to the LDPE leads to increase the modulus of elasticity, tensile strength, tensile strength at break, shore hardness on other hand it decreases the % elongation at break, and for the impact strength.

الخلاصة

في البحث الحالي تم تصنيع المواد المتراكبة بواسطة مزج البولي اثلين الواطئ الكثافة مع نسب وزنية مختلفة من(ثنائي اوكسيد التيتانيوم، اوكسيد الحديد)وذلك لإيجاد أحسن الخصائص باستخدام جهاز الباثقة الأحادية حيث تم تشغيلها عند درجات حرارة تتراوح بين (١٥٠-١٧٠) درجة مئوية.تم أجراء العديد من الفحوصات(الاتلافية)حيث تم أجراء فحص الشد،الصدم،الصلادة والانحناء على النماذج المحضرة ووجد إن إضافة مزيج من ثنائي اوكسيد التيتانيوم،اوكسيد الحديد إلى البولي اثلين واطئ الكثافة قد أدى إلى زيادة كل من معامل المرونة ،إجهاد الشد،إجهاد الشد عند الكسر وتقليل النسبة المئوية للاستطالة عند الكسر.أما بالنسبة إلى فحص الصدم فقدد وجد إن إضافة ثنائي اوكسيد التيتانيوم واوكسيد الحديد إلى البولي اثلين الواطئ الكثافة قد أدى إلى تقليل مقاومة المواد للصدم.لذلك فان البولي اثلين الواطئ الكثافة وبدون إضافة قد أعطى أعلى قيمة للصدم.

Key Words : Ldpe, Weathering, Tio_2, Fe_2o_3.

Introduction

Low density polyethylene LDPE is the most important thermoplastic polymer, which is of practical use in many industrial applications. Polyethylene is the most important thermoplastic polymer. Low-density polyethylene (LDPE) is produced by the polymerization of highly purified ethylene at very high pressure in the presence of a trace of oxygen [1, 2, and 3]. It is flexible and has a lower maximum temperature range than high-density polyethylene. It finds use in many industrial applications and has good resistance to water, alkalis and inorganic salt and also has good resistance to moderate resistance of false oil and it has a moderate resistance to petroleum [4].

*Dep. of Chemical Eng. Univ. of Tech.

https://doi.org/10.30684/ etj.26.9.2
University of Technology-Iraq, Baghdad, Iraq/2412-0758

Since the very early stages of the development of the polymer industry it was realized that useful products could only be obtained if certain additives are incorporated into the polymer matrix [5]. Additives used in plastic materials are normally classified according to their specific function, rather than on a chemical basis [6]. Mixtures containing one or more polymers and various ingredients such as stabilizers, filler, and colorant [7, 8]. Colorants are added to produce color in the polymeric part; they are separated into pigments and dyes [9]. The particular color desired and the type of polymer will affect the selection of the colorants [10]. Many workers investigated the phsico-mechanical properties of filled LDPE with additives. **Malik**.[11], studied the mechanical properties of PE extended to draw ratio in the (20-40) range have been determined and compared with corresponding properties of the polymers containing particulates including TiO_2 rutile, carbon black, iron oxide and mica**.** **Young**.[12], studied the dispersion of titanium dioxide agglomerates with the linear low density polyethylene (LLDPE) by using a cone and plate device installed within a temperature controlled oven.**Tibor and James** [13], studied the effect of colorants on the mechanical properties of PE. Five pigment were investigated (titanium dioxide, cadmium yellow, iron oxide red, carbon black and phthalocyanine blue **. Flores**[14], studied the influence of filler structure on micro hardness of carbon black-low density polyethylene composites **Surat and Yusuke** [15], studied the solubility of carbon dioxide / low density polyethylene (LDPE)/titanium dioxide (TiO_2) composite was measured using a magnetic suspension balance (MSB) a temperature from 423 to 473 K^0 and pressure up to 15 Mpa.In the present work a composite material was fabricated using LDPE with different weight percentage of Fe_2O_3 and TiO_2 by using single screw-extruder to obtain material with desire mechanical properties.

Experimental

materials

In this work two main types of materials were used; Commercial LDPE of a density equal to 0.9235 gm/cm^3. And inorganic pigment (TiO_2 rutile type and the particle size used equal (60.40) µm. and Fe_2O_3, the type of iron oxide used is hematite and the particle size is equal 40.62(µm))

Methods

The single-screw extruder machine was used to mix raw materials (LDPE and pigment).The compounding process involves mixing of different weight percent of LDPE and inorganic pigment. The weighted samples were inserted to a single screw machine at temperature ranging from (150-170)^{o}C and rotation increases from (0-60) r.p.m..The compounding time involved was less than (5 min).After compounding process was completed (i.e., the melt became homogenous), the homogenous mixture then pressed in the hydraulic press by applying temperature and pressure at the same time the temperature applied to the upper and lower sides of mold while the sample was still under the applied pressure. (10MPa) and temperature (150 ^{o}C) for a (5min).A sample sheet with dimension (290x 205x4) mm was obtained .the test were done on sets of the LDPE with different formulations as shown in table (1)

The prime consideration in determining the general utility of a polymer is its mechanical behavior, tensile properties, impact strength, hardness and modulus of elasticity were carried out for examining the mechanical properties of the samples ,

The tensile strengths at break values were determined by using tensile test according to ASTM D638 [16].Shore D hardness was used to determine the hardness of the polymer materials, maximum Test Load: 50 N at Shore According to ASTM. Charpy test was used to determine the impact strength of the polymeric material, the samples of impact test were notched by (notch instrument) according to ASTM(D256-87)[16] .Three point system was used to determine the modulus of elasticity of low-density polyethylene with TiO_2 and Fe_2O_3. to ASTM (D790m-86)

Results and Discussion:

Tensile Test

Figure (1) shows the variation of tensile strength (σ_u) of LDPE with different wt. %.of TiO_2 and constant Fe_2O_3 content (7% wt) at different exposure times between (0-250) hrs. Figure (2) shows the variation of tensile strength

(σ_u) of LDPE with different wt. %.of Fe_2O_3 and constant TiO_2 content (7% wt). From these figures (1-2) it is clearly seen that after the addition of pigment as a filler to LDPE the tensile strength increases with increase of wt% pigment (TiO_2 and Fe_2O_3) added. This may be due to the fact that increase the wt. % of pigment particles will lead to a better adhesion between polymer and filler.

Figure (3) illustrates the relation between the tensile strength at break (σ_{TB}) of LDPE at different wt. % of TiO_2 and constant % Fe_2O_3 (7%). Figure (4) illustrates the relation between the tensile strength at break (σ_{TB}) of LDPE at different wt. % of Fe_2O_3 and constant % TiO_2 (7%). From these figures (3 and 4) it is clearly seen that increasing %pigment (TiO_2 and Fe_2O_3) content leads to an increase in the fracture stress. This may be due to the binding forces between molecules .This leads to decrease in the elastic movement of polymer chain which leads to increase the fracture strength [6]. This results is good agreement with results obtained by Tibor and and James [13].

Figure (5) shows the variation of % elongation at break (ζ_B) of LDPE at different wt. % of TiO_2 and constant % Fe_2O_3while (7%) Figure (6) shows the variation of % elongation at break (ζ_B) of LDPE at different wt. % of Fe_2O_3 and constant % TiO_2 (7%) at different exposure times between (0-250) hrs. From these figures (5 and 6), it is clearly seen that increasing of wt.% of pigment particles ($TiO_2$and Fe_2O_3) lead to decrease in the %elongation at break, because the elongation at break of polymer composite depends on the elongation of filler and polymer[9], furthermore cracks can form either within or around the particles. Therefore, the voids and cracks do not transfer stress, making the material more compliable and thus lowering the material elongation.

Impact strength

Figure 7 shows the variation of impact strength of LDPE at different wt.% of pigment particle (TiO_2) and constant at % Fe_2O_3 (7%). Figure 8 shows the variation of impact strength of LDPE at different wt. % of pigment particle (Fe_2O_3) and constant % TiO_2 (7%).The results show that increasing the wt.% of pigment $TiO_2$and Fe_2O_3 lead to decrease in the impact strength, also increase of pigment causes a decrease in samples toughness, because the addition of pigment particle causes an increase in the strain rate which leads to carry part of fracture energy and it will act as crack growing that leads to fracture and it will distribute the applied fracture stress. Therefore the toughness of the polymer decreases and its ability to absorb and dissipate energy decrease, thus the polymer needs low impact energy to fracture [7].

Hardness Test: -

In the present work Durometer hardness type (shore –D) was used to measure the hardness. Figure 9 shows the variation of hardness test of LDPE at different wt % of TiO_2 and at constant % Fe_2O_3 (7%). Figure 10 shows the variation of hardness test of LDPE at different wt % of Fe_2O_3 and at constant % TiO_2 (7%). Figure (9 and 10) show that the shore hardness increases with the increasing of wt. % of pigment particle (Fe_2O_3 and TiO_2) ranging between (9-15) %. As the wt. % of pigment added increases the ability of polymer to resist plastic deformation increase [10]. It is well known that the hardness originally depends on some important factors such as: type of the linking forces between the molecules and type of the surface and other effective conditions.this results in good agreement with result obtained by Malik [11].

Bending Test

The modulus of elasticity (E) 1s a measure of the stiffness or rigidity of materials depending upon strength of interatomic bonds and compositions .

Figure 11 illustrates the relation between the modulus of elasticity of LDPE at different wt. % of TiO_2 and constant % Fe_2O_3 (7%). Figure 12 illustrates the relation between the modulus of elasticity of LDPE at different wt. % of Fe_2O_3 and constant % TiO_2 (7%). From these figures (11 and 12) it is clearly seen that the increase of wt.% of pigment particles (TiO_2 and Fe_2O_3) leads to increase in the modulus of elasticity. This increase in modulus of elasticity is due to the increase of linking force between the molecules of the matrix and thus become more elastic which leads consequently to a smaller deformation of sample, ultimate increase of modulus of elasticity[5].

Conclusion:

The experimental results obtained from this lead to the following conclusions:

1-Pure LDPE has lower modulus of elasticity, tensile strength, tensile at break and shore hardness than pigmented LDPE.

2-LDPE with pigment (TiO_2 and Fe_2O_3) gives higher values of tensile strength and tensile strength at break than pure LDPE. Also shore hardness of polymer matrix was improved. On other hand pure LDPE has a higher value of elongation at break and impact strength.

References

[1]. Donald R, Askelane, and Pradeep P. PhuleThe Science and Engineering of Materials ", John Wiley and Sons , Four Edition ., New York , 2003.

[2]. Crum,N.G.Mc,C.P.,Buckleg, and C.B.,Bucknall," Principles of Polymer Engineering ",John Wiley and Sons , 2nd ed., New York , 1997.

[3]. Polymer Hand Book ,edited by James E. Mark., press New York .oxford 1999.

[4]. William D. Cr., Jr.,"Materials Science and Engineering An Introduction ",John Wiely and Inc,2003.

[5]. The Lactite design guide for bonding plastics , "Plastics" ,2004, available oneline at : http://www.tvk.hu/tvk/multi/plastics/tipolen. . en.pdf.

[6]. Mascia, L., " The Role of Additives in Plastics ", Edward Arnold, London, 1974.

[7] John, T. L., JR, "Thermoplastic Polymer Additives ", Theory and Practice, Bensalem, Pennsylvania, Marcel Dekker, Inc., New York and Basel, 1989.

[8]. Charles, H.A., "Modern Plastic Handbook ", Mc-Graw Hill company,New York ,2000 .

[9]. Stepek J.. H.Daoust; "Additives for Plastics " springer-verlag, New York, 1983

[10]. Temple C.P., "Pigment Hand book ", Applications and markets, Vol. II, John Wiley and sons, 1973.

11]. Malik T,M,"Property stabilization in filled, drawn polyethylene ", Vol. 43, lssue 3, pages 543-551, 1991.

[12]. Young,Jin,L, "Analysis of titanium dioxide agglomerate dispersion in linear low density polyethylene and resulting properties of compounds, Vol. 35, lssue 12,pages 1037-1045, 1995.

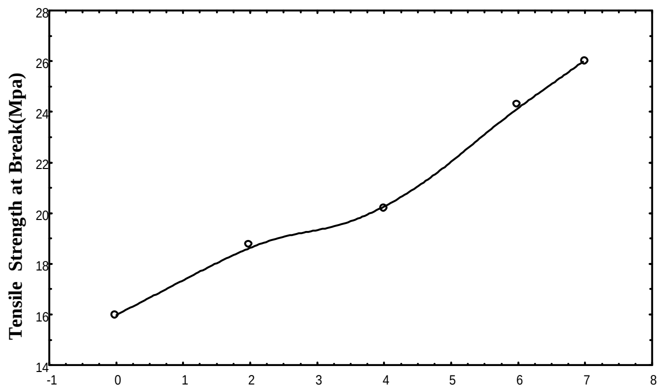
[13]. Tibor N., James L.W., "the effect of colorants on the properties of rotomolded polyethylene parts ", Vol. 36, lssue 7, pages 1010-10181, 1996.

[14]. Flores, M.E. cagiao,"In fluence of filler structure on microhardness of arbon black – polymer composites ", vol. 79, lssue 1, pages 90-95,2000.

[15]. Surat Areerat and Yusuke Hayata et.al,"solubility of carbon dioxide in polyethylene / titanium dioxide composite under high pressure and temperature ", Vol 86,lssue 2, pages 282-288,2002.

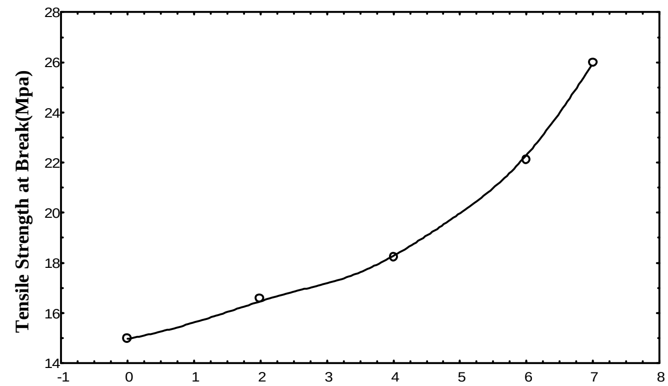
[16]. Annual book of ASTM,Section8,Vol.08.01Plastic,"ASTM.", Philadelphia,1989.

[17]. ASTM ,D 790 M,P.(290-297),1986.



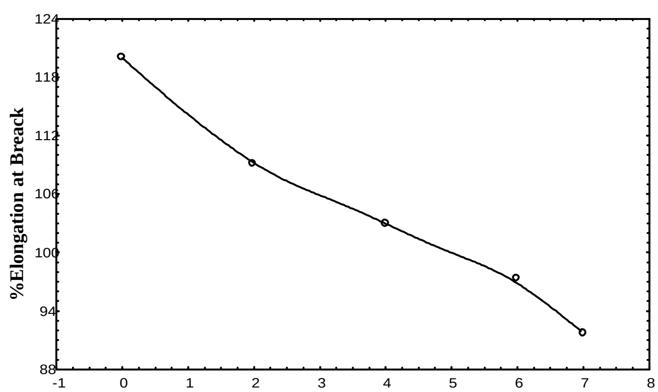
Weight percent of TiO_2

Figure (3) Tensile strength at break of LDPE as a function wt.% of TiO_2 and constant Fe_2O_3 content (7% wt)



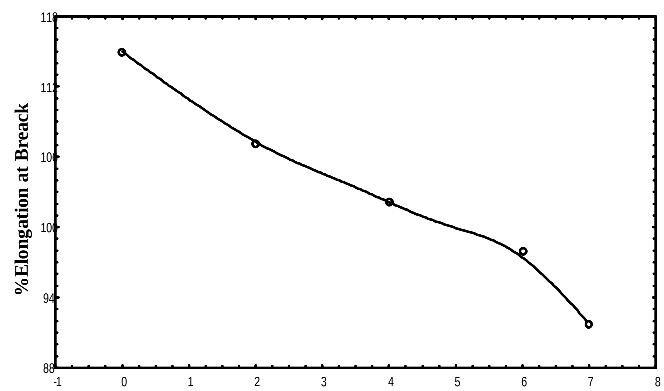
Weight percent of Fe_2O_3

Figure (4) Tensile strength at break of LDPE as wt.% of Fe_2O_3 and constant TiO_2 content (7% wt)



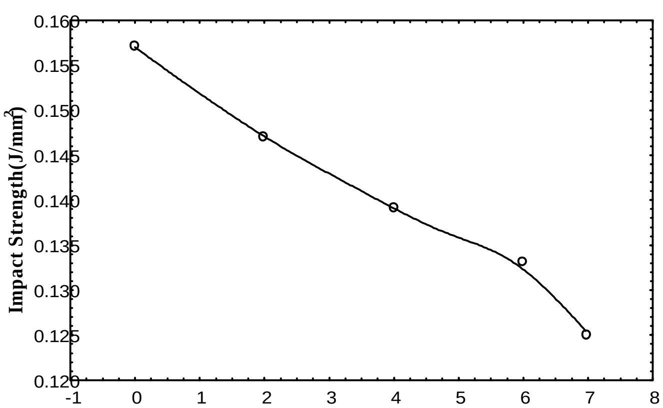
Weight percent of TiO_2

Fig. 5 %Elongation of LDPE as a function of TiO_2 (Wt.%) and constant content Fe_2O_3 (7%wt)



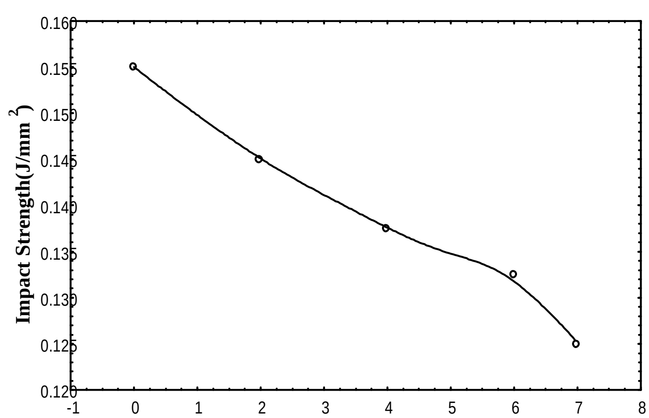
Weight percent of Fe_2O_3

Fig. 6 %Elongation of LDPE as a Function of Fe_2O_3 (Wt.%) and constant TiO_2 content (7% wt)



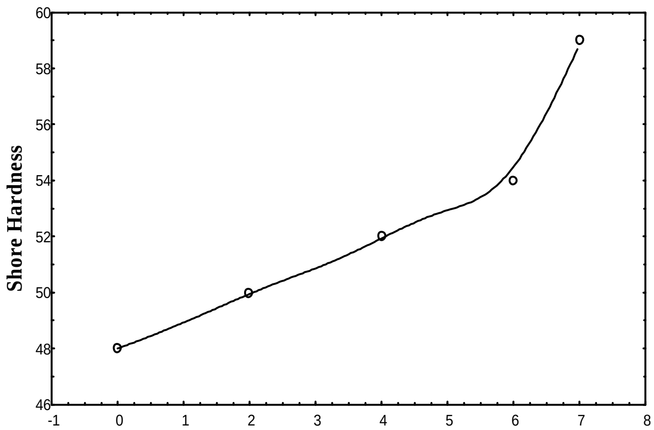
Weight percent of TiO_2

Fig. 7 Impact strength of LDPE as a function of TiO_2 content (Wt.%) and constant Fe_2O_3 content (7% wt)



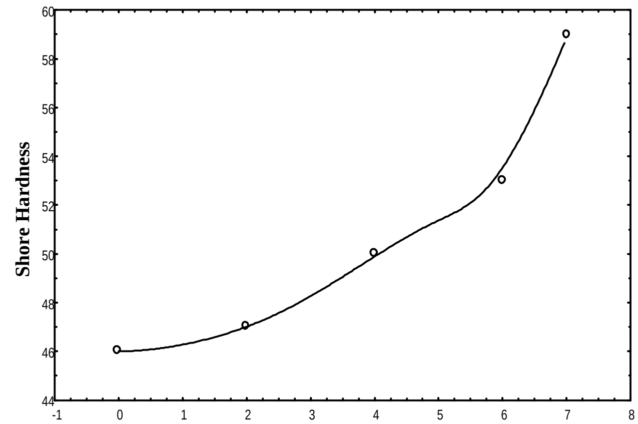
Weight percent of Fe_2O_3

Fig. 8 Impact (7% wt) of LDPE as a function of Fe_2O_3 content (Wt.%) and Constant TiO_2 content (7% wt)



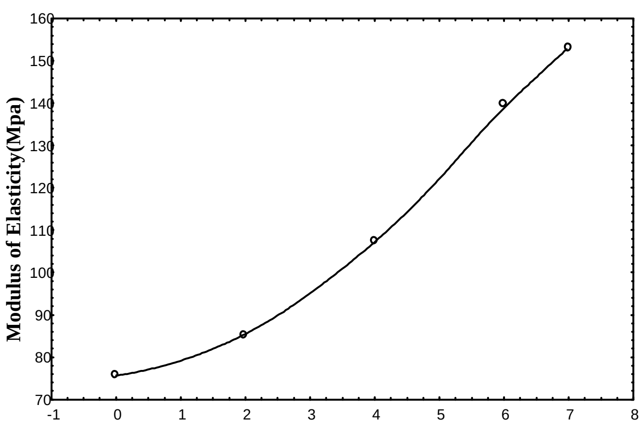
Weight percent of TiO_2

Fig.9 shore hardness of LDPE as a function of TiO_2 content (Wt.%) and constant Fe_2O_3 content (7%)



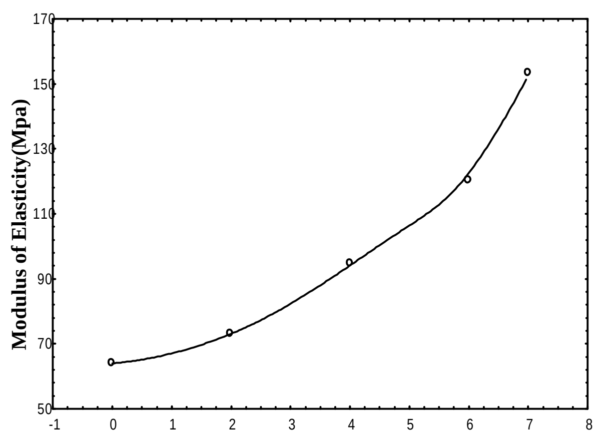
Weight percent of Fe_2O_3

Fig. 10 shore hardness of LDPE as a function of Fe_2O_3 content (Wt.%) and constant TiO_2 content (7%)



Weight percent of TiO_2

Fig. 11 Modulus of elasticity of LDPE as function of TiO_2 Content (Wt.%) and constant Fe_2O_3



Weight percent of Fe_2O_3

Fig.12 Modulus of elasticity of LDPE as function of Fe_2O_3 Content (Wt.%) and constant TiO_2 content(7% wt).