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Effect of some organic fillers on the mechanical properties of high density polyethylene

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Abstract

In this paper , the mechanical properties of high density polyethylene (HDPE grade M624) produced by SCPI / Basrah – Iraq , mixed with the wood flour and bagasse as fillers with 10-50 % w/w have been studied . The maximum tensile strength was observed at 10% w/w of fillers ratio . The elongation , impact strength and fracture energy were decreased with increasing of fillers ratio while the Young modulus and hardness were increased .

Introduction

Polyethylene is a thermoplastic polymer of softening at about 80 – 130ºC with a density less than of water , it is commercially produced from polymerization of ethylene , the polymer being produced by this route in 1933 . Polyethylenes are classified to three main types ; low density (LDPE) , medium density (MDPE) and high density (HDPE) [1] . One of the most important properties of polyethylene is the mechanical properties that depends upon the molecular structure and special arrangement of the molecules [2] . A distinct advantage of organic fillers of synthetic or natural origin over inorganics in their low density resulting from regional availability may be an additional advantage especially for fillers of natural origin (wood flour , rice hulls and vegetable fibers) , some organic materials have been useful as additives in thermosets and thermoplastic polymers [3] .

Many studies have been published concerning the study of the mechanical properties of polyethylene with cellulosic fillers [4 -8] .

This study investigates the effect of cellulosic fillers (wood flour and bagasse) with 10 -50% w/w ratio on mechanical properties of high density polyethylene HDPE grade (M624) .

Experimental:

A- Materials:

1- High density polyethylene (HDPE) grade M624 was supplied by state company for petrochemical industries / Basrah – Iraq (SCPI) .

2- Cellulosic fillers ; wood flour from the wood tree (W.F.) and bagasse from the waste of sugar factory in Messan (Bag.) . The cellulosic fibers were gride by grinder (powder with mesh size of 45 µm) .

B- Preparation of composites :

Total of 60 gm were mixing by rheomix 600 which attached to Haake 90 rheochorder torque rheometer . Total time of mixing 15 min. , rpm is 64 and temperature 175C°, percent of fillers in HDPE are 10-50% w/w . All samples were compression molding in a laboratory press P.H.I. at 160-175 C° under 5 ton for 3 min. and then raise the compression to 15 ton for 6 min. , these samples were cut by automatic hollow die punch to dumble shap . Mechanical measurements were made on an Instron tester (model 1193) at room temperature . Crosshead speed is 50 mm/min. and chart speed is 10mm/min.

Result and discussion :

The mechanical properties of polymer depend on its crystallinity that decreases with more branches in the polymer chain . Crystallinity is interesting to note that the homopolymer grades have relatively high ultimate tensile strength , high yield stress and high elastic modulus ; while they have relatively lower strain at break and at maximum load [9] .

In this paper , the mechanical properties of M624 and its composites were studied ; fig. (1) shown the tensile strength of polymer and its composites , the polymer has tensile strength greater than its composites 28.6 MPa . When 10% w/w of fillers addition , the tensile strength increased to 29.1 MPa for W.F. and 28.9 MPa for bag. Then decreased with 20 – 50 % w/w with the increasing a fillers ratio because the linearity of the polymer chains that lead to decreased of the free volume and increase of chains interaction [8 ,10]. The effect of fillers on elongation of polymer was shown in fig. (2) ,

elongation of polymer 65% is greater than its composites 37 , 42 % for 10 %w/w and 10.1 , 11.8 % for 50%w/w of W.F and bag. addition , that is because of the decreasing of function groups at the fillers molecules [10-11] .

From fig. (3) that effective of fillers on Young modulus of polymer , the Young modulus of polymer has a value of 180 MPa , after 10%w/w of fillers ratio added to the polymer matrix were 244 MPa for W.F. and 237 MPa for Bag. , at 50% the Young modulus was 478 , 452.7 MPa for W.F and Bag. respectively , the Young modulus of polymer matrix is less than Young modulus of its composites as the increasing the interaction between a polymer matrix and fillers because the decreasing of functional groups in the fillers [11,12] .

Fig. (4) show the hardness of polymer and its composites , polymer hardness is 65 that less than of its composites 67 , 70 to 10%w/w and 88.5 , 92 to 50%w/w of W.F. and Bag. addition ratio , the polymeric hardness increases with the increasing a filler ratio because of the increase of a polymeric density and decreasing on the free volume among polymer chains at increasing of a filler ratio [13] .

Impact strength of M624 and its composites are shown in fig. (5) , impact strength of polymer matrix is 52 KJ/m^2 that is greater than its composites 43.5 , 40.8 KJ/m^2 for 10%w/w of W.F. & Bag. and 19.3 , 14.1 KJ/m^2 for 50%w/w of W.F. & Bag . respectively , the impact strength of polymer decreases with the increasing of filler ratio because of filler nature [8, 14] .

Finally , fig. (6) show the fracture energy of polymer and its composites , the fracture energy of polymer 34.6 J that is greater than of polymeric composites 8.1 , 9.8 J at 10%w/w of fillers concentration addition 1.15 , 1.7 J at 50%w/w of W.F. & Bag. respectively as the relative shortness of the filler that reduce the effective loading ability of the filler in the polymeric matrix [4 , 8,15 -16] .

Conclusion :

This paper studies the mechanical properties of high density polyethylene grade (HDPE M624) using the wood flour and bagasse as fillers with 10 – 50% w/w of filler ratio . This study shows that decreasing of tensile strength , elongation , impact strength and fracture energy while Young modulus and hardness are increasing with increased of filler ratio .

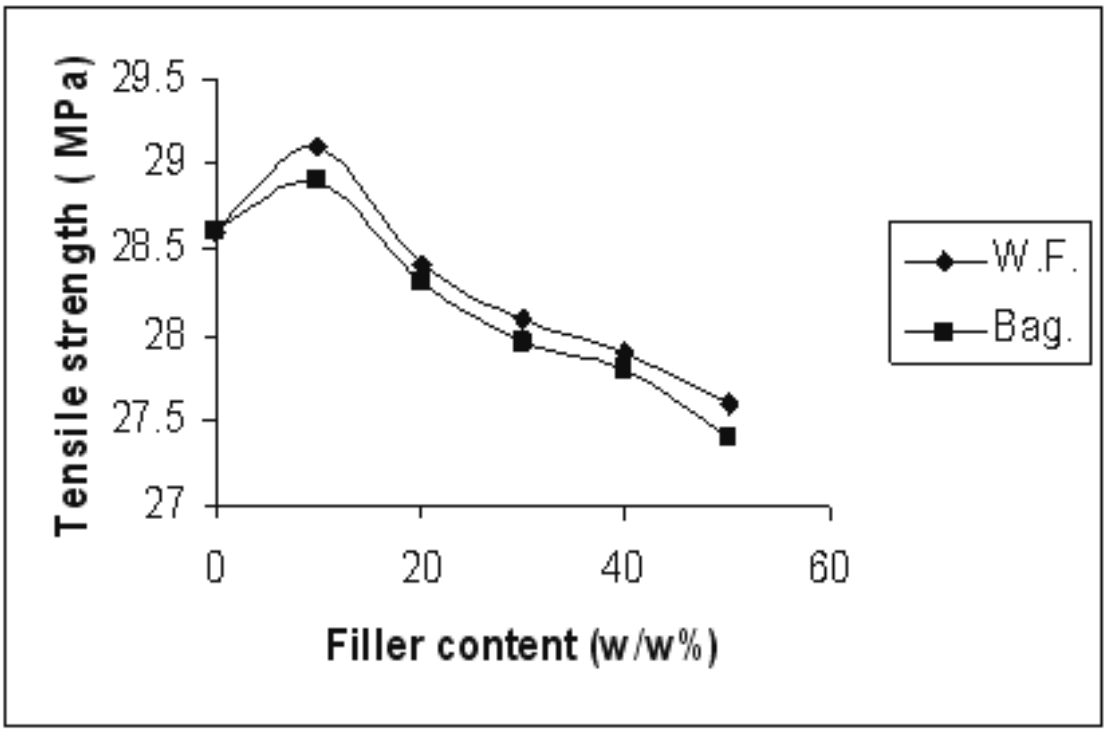

Fig. (1) effect of filler on tensile strength of HDPE

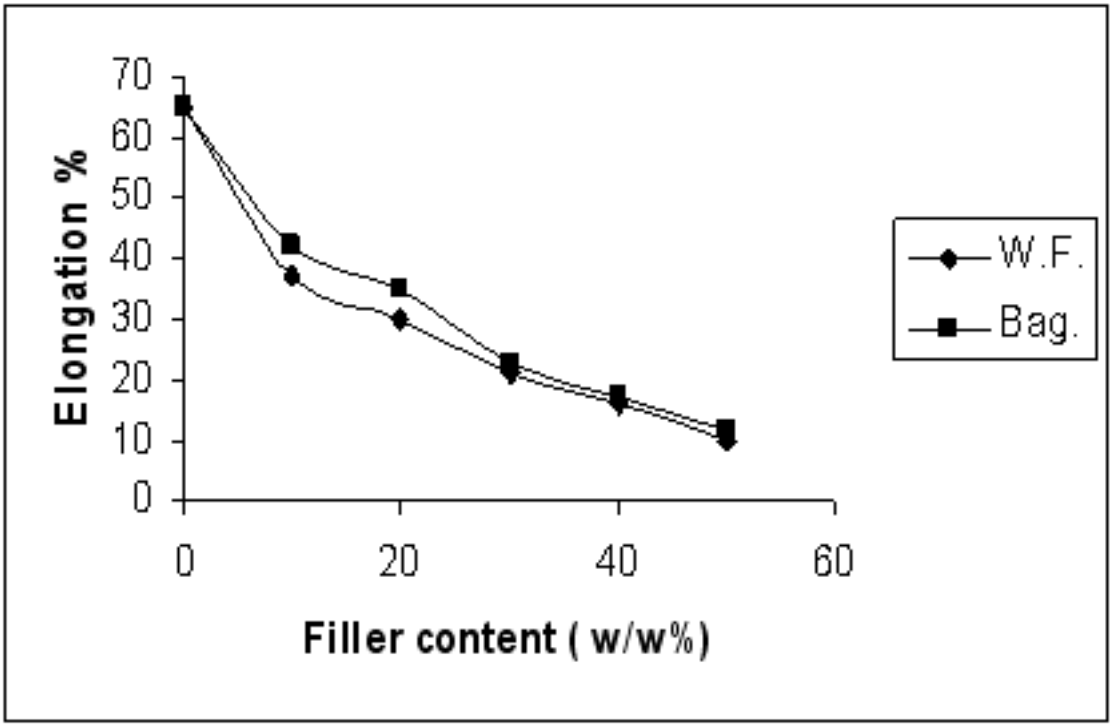

Fig. (2) effect of filler on elogation of HDPE

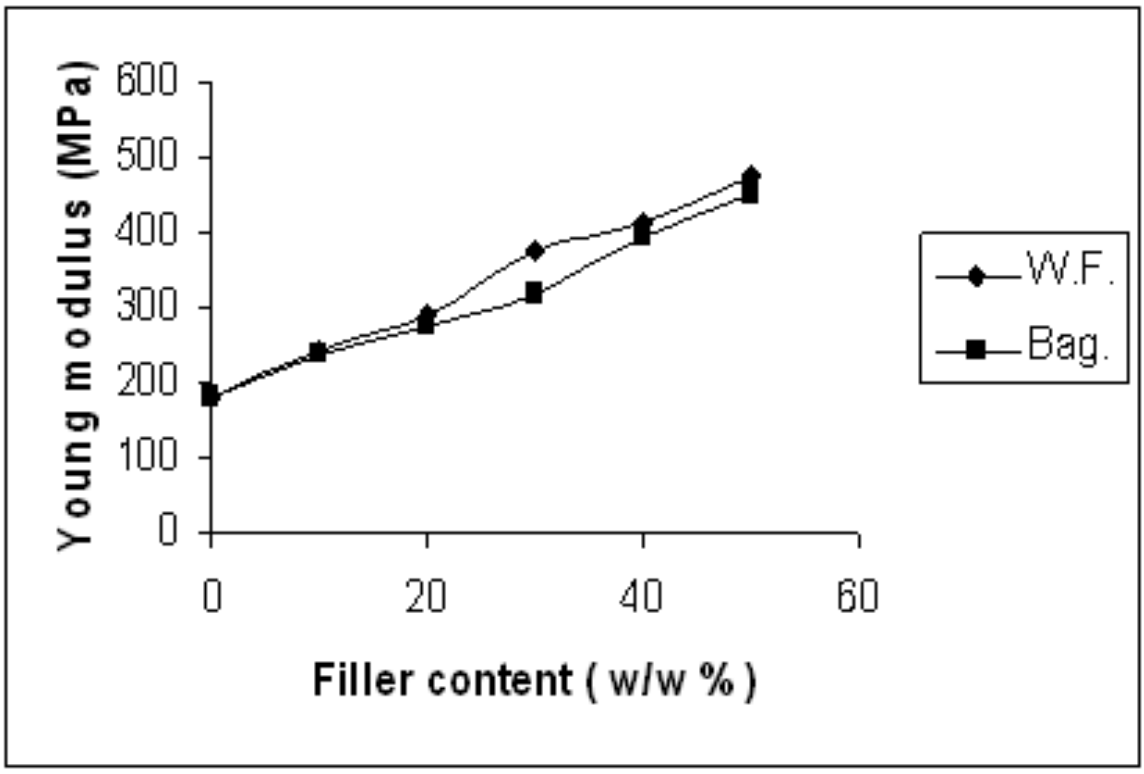

Fig. (3) effect of filler on Young modulus of HDPE

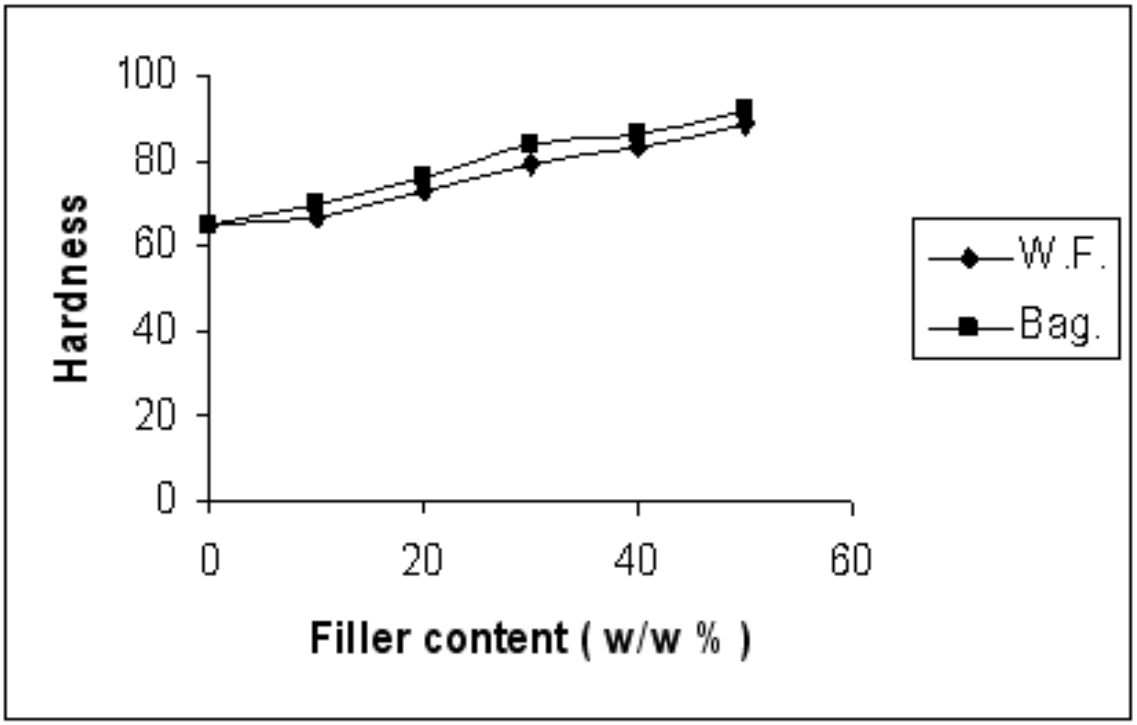

Fig. (4) effect of filler on hardness of HDPE

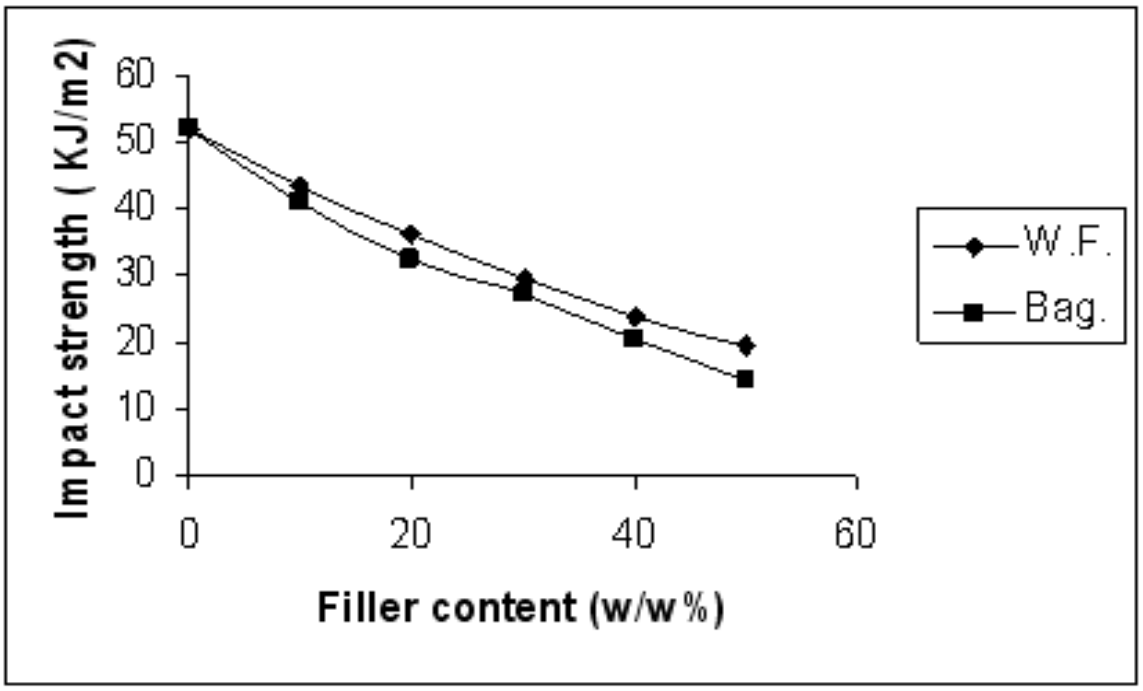

Fig. (5) effect of filler on impact strength of HDPE

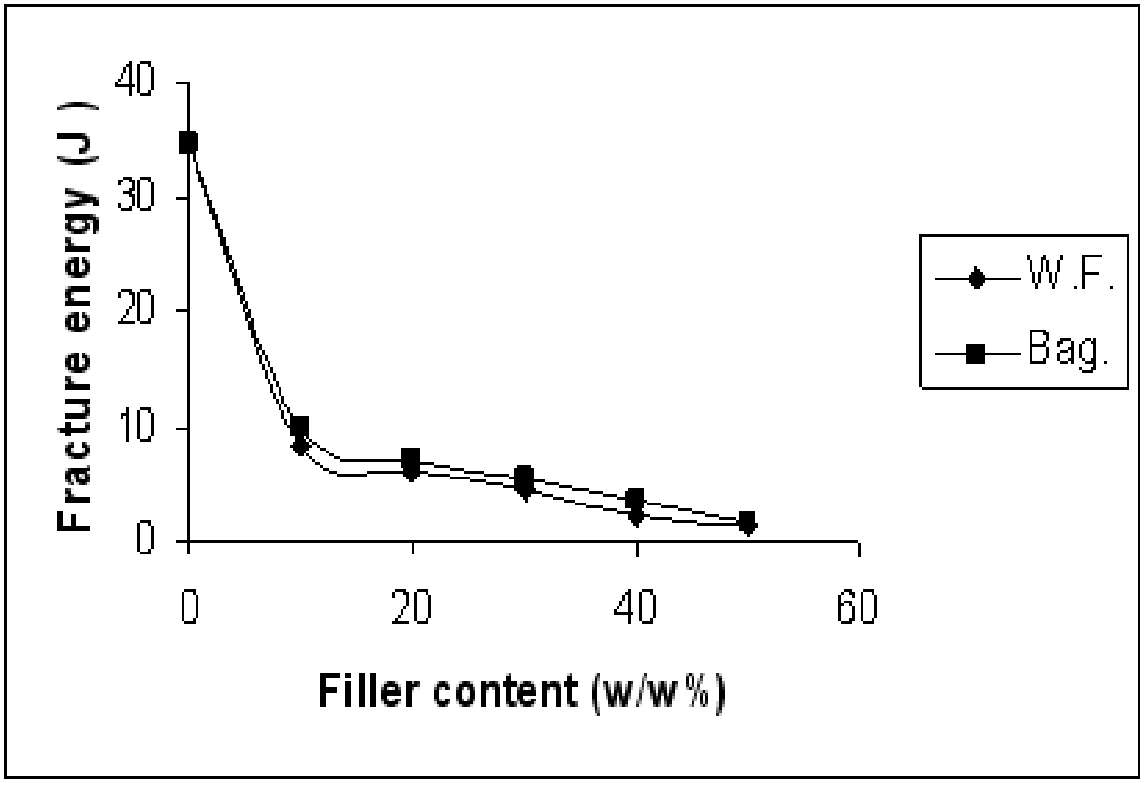

Fig. (6) effect of filler on fracture energy of HDPE

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تأثير بعض المائيات العضوية على الخواص الميكانيكية للبولي اثلين عالي الكثافة

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الملخص

في هذا البحث تم دراسة الخواص الميكانيكية لمزائج البولي أثيلين عالي الكثافة صنف M624 والمنتج محليا في الشركة العامة للصناعات البتروكيمياوية / البصرة – العراق باستخدام نشارة الخشب والبكاس كمالئات بنسب ١٠–٥٠ % (وزن / وزن) . وكانت نتائج الدراسة إن قوة الشد تزداد عند النسبة ١٠% بينما تقل عند النسب الأخرى من المالئ ٢٠ – ٥٠% وتقل قيم الاستطالة وقوة التصادم وطاقة الكسر بزيادة نسبة المالئ المضاف , إضافة لذلك يزداد معامل يونك والصلادة بزيادة نسبة المالئ المضاف .