Studing The Mechanical Properties Of Ternary Blends Of Hdpe/Pp/Abs

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Abstract :

In this work a type of polymer blend has been prepared from mixing different percent (40,50,60, and 70) % of High-density polyethylene, polypropylene and adding 6% weight percent of acrylonitril-butadiene-styrene by using single-screw extruder. The extrusion process concentrated on the homogeneous mixing manner among materials through a regular selection of machine screw revolution per minute and temperature used in extrusion process. Some of mechanical properties such as impact strength, modulus of elasticity and shore hardness of polymer blend, were determined at different weight fraction of blend. It was found that the addition (6%wt) of ABS to the binary blends HDPE/PP leads to increase the modulus of elasticity, the impact strength and shore hardness.

On the other hand increasing % HDPE content from 40 to 70wt% in HDPE/PP ternary blends leads to increase the modulus of elasticity from 166.35 Mpa to 186.25 Mpa, and impact strength increase from o.o52 to o.o6 J/mm^2 while decreases the shore hardness from 89 to 69.

Keywords: polymer blend, high density polyethylene, polypropylene

الخلاصة

في البحث الحالي تم تحضير خلائط بوليمرية جديدة والتي هي عبارة عـن مخلـوط بـوليمري، يتكون من مزج نسب وزنية مختلفة%(60,70 ,40,50) من البولي اثلين العـالي الكثافـة مـع البـولي بروبلين مع إضافة نسبة وزنية%(6) من اكريلونتريل-بيوتا دين-ستايرين(وذلك باسـتخدام جهـاز الباثقـة المنفرد).تم استخدام عملية البثق في تحضير المواد المتراكبة وذلك بواسطة استخدام ماكنة البثـق أحاديـة اللواب حيث ركزت على أسلوب الخلط المتجانس بين المواد من خلال تحديد سرعة دوران اللولب الماكنـة ودرجات الحرارة المستخدمة في عملية البثق. وبعد ذلك جرت دراسة بعض الخصائص الميكانيكيـة مثـل مقاومه الصدم ،معامل المرونة وصلادة شور ولجميع خلائط بوليميرية المحضرة. والنتائج التي تم الحصول عليها أوضحت عند إضافة%(6) من اكريلونتريل-بيوتا دين-ستايرين الى خلائط ثنائي(البولي اثلين العالي الكثافة –البولي بروبلين) ادى الى زيادة معامل المرونة ,قوه الصدمة وصلادة شور. من ناحية أخرى وجـد بأن زيادة اضافة البولي اثيلين عالي الكثافة من(40 الى 70)% إلى خلائط ثلاثية (البـولي اثيلـين عـالي الكثافة-البولي بروبلين - اكريلونتريل-بيوتا دين-ستايرين) تحسنت الكثير من الخواص الميكانيكيـة حيـث ادى الى زيـادة معامـل المرونـة مـن(166,35)إلـى (186,25)ميكاباسـكال وقـوه الصـدمة مـن (0,053الى0,060)جول/مليملتر^2 . بينما قلت صلادة شور من (89) إلى (69).

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1-Introduction

Mixing of two or more different polymers together makes it possible to achieve various property combinations of the final material – usually in a more cost-effective way then in the case of synthesis of new polymers. Therefore, polymer blends are substantial and growing part of polymeric materials. Recently, polymer blends also become the results of material recycling of mixed plastic scrap [1, 2].Polymer blends are either miscible or immiscible; the properties of immiscible polymer blends are mainly controlled by their phase morphology. Two major classes of phase morphologies can be distinguished in a binary two-phase blend, isolated particles dispersed in a matrix and a two-phase continuous morphology. In the former, nonconnected droplet, platelets, rods, or fibers of one phase are distributed in the matrix of the other phase. The physical properties of the blends having phase morphology are mainly controlled by the properties of the matrix except in toughened plastics and in oriented structures where the characteristics of the dispersion (size, volume fraction, and spatial distribution) play a key role in controlling the toughness of the blend [3].

A number of studies on HDPE/PP blends have been published**. Robertson and Paul** [4] studied the yield tensile strength, elongation at break, and the modulus of melt blends of low-density polyethylene, high-density polyethylene, and polypropylene over the entire ternary composition range. High-density polyethylene (PE) and isotactic polypropylene (PP) were melt-blended in the following percentages of PE by weight: 0, 10, 33.3, 40, 50, 66.6, 90, and 100, For these blends **Oscar et.al** [5] obtained data on shear stress vs shear rate; tensile modulus and strength; density; and rates of water-vapor transmission for films. **Ezio et.al** [6] studied the crystallization behavior of high density polyethylene/isotactic polypropylene blends (HDPE/PP) .Also **David et al.** [7] studied the characterization of blends of high density polyethylene with isotactic polypropylene, the techniques include optical microscopy, density measurements and differential scanning calorimetry (DSC) .**Chang and Sung** [8] studied the tensile properties and morphology of the polyolefin ternary blends of ethylenepropylene-diene terpolymer (EPDM), polypropylene and high density polyethylene. **Mitsuyoshi and Youtoku** [9] studied three kinds of isotactic polypropylenes with different MFI were melt-blended with three kinds of high-density polyethylenes with different MFI using a screw extruder and the dynamic viscoelastic properties.**Zeng et al.** [10] studied the effect of matrix toughness and dispersed elastomer phase on the brittle-ductile transition in PP/HDPE/SBS blends. **Tai et al.** [11] blended PP with 20% LDPE or 20% HDPE using a single screw extruder. The impact strength of PP was reduced by the addition of HDPE but was marginally improved by LDPE. LDPE droplets decreased the spherulite size and ultimate tensile strength of PP. **Aimeline et al.** [12] studied a polypropylene/high-density polyethylene blend containing 70 wt % polypropylene was prepared and compatibilized via the addition of maleic anhydride grafted polypropylene and polyethylene.Also Crystallization behaviors, spherulite growth and structure, and the crystallization kinetics of polypropylene (PP)/ethylene-olefin copolymer (mPE)/high-density polyethylene (HDPE) ternary blends and of mPE/HDPE binary blends have been studied using polarizing optical micrography (POM) and differential scanning calorimetry (DSC) by **Man and Byung** [13]. In this study , the changes in mechanical properties (bending , hardness, impact properties) of ternary blends of high density polyethylene (HDPE)/polypropylene (PP)/ poly acrylonitrite – butadiene – styrene (ABS) are investigated.

2-Experimental

2-1 Materials

Commercial polypropylene was used was supplied by SABIC Saudi Arabia. The flow index and the density of the material were 11 gm/min and 0.908 gm/cm^3 respectively.

Plastic. The density of the material was 1.01 gm/cm^{-3}. Commercial acrylonitril–butadiene–styrene was supplied by the National Company for Chemical and

Commercial High-Density Polyethylene was used was supplied by the National Company for Chemical and Plastic .The flow index and the density of the material were 8.4gm/10min and 0.963gm/cm^3 respectively.

2-2Method

All blends were prepared by the melt mixing technique using Brabender plasticorder (single screw extruder Betol BM 1820 extruder), which is available at the National Company for Chemical and Plastic Industries in Baghdad.The single-screw extruder machine was used to mix raw materials(HDPE/PP/ABS) The compounding process involves mixing of different weight percent of HDPE/PP/ABS blend. The weighted samples were inserted to a single screw machine at temperature ranging from 190-220^{o}C and screw speed increases from 0-30 RPM.The compounding time involved was less than (5 min). This mixture was then fed into 25 mm single screw extruder. The barrel temperature was monitored and controlled by thermostats. The die temperature was also controlled by a thermostat and was adjusted, together with barrel temperature to yield uniform output, the extrusion condition were listed in table (1). The extruder produced in the form of about 2 mm diameter monofilament was cooled in water. The monofilament produced by using a screw speed was uniform and opaque, which was cut in the form of granules of 3-4 mm length with the help of granules.

Compression molding technique was performed to obtain testing sample. The CININATI hydraulic press was used with maximum load of 15 ton and working area of 0.4*0.3 m, available in the National Company for Chemical and Plastic Industries in Baghdad. The mold used for pressing the polymer blends has dimensions of 30*30*4 mm. It is made of steel and also uses two aluminum plates of 30*30 mm.

The prime consideration in determining the general utility of a polymer is its mechanical behavior. Impact strength, hardness and modulus of elasticity were carried out for examining the mechanical properties of the samples , in this work the impact resistance was determined using Charpy impact test instrument No – 43 – 1, made by Testing Machines, Inc. Test specimens with dimension of 10x3x55 mm were used in present work according to the rest specification of ASTM (D256 – 87) [14]. Shore D hardness was used to determine the hardness of the polymer materials. Tester type 7201. Test was carried out according to

ASTM (D 2240) and (ISO/R 868) the specifications of 7201.In this work a three point system was used to determine the modulus of elasticity of HDPE/PP/ABS blends according to ASTM D790m-86 [15]. The ratio of span to depth is (32:1) according to the standard specification of ASTM. All the specimens of bending test of HDPE/PP/ABS blends before and after exposed have a depth of 10 mm and thickness 3mm.

3. Results and Discussion:

3.1 Hardness Test: -

Hardness is the resistance of a surface to local deformation by another body. It is a relative property rather than an absolute property[16]. Figure 1 shows the shore-hardness of HDPE/PP/ABS blends as function of HDPE content. The results show that increasing % HDPE content leads to decrease the shore hardness, This is due to the nature of polymer structure, which consist of a long branched polymer chain the molecules arrangement and the cross linked polymer have strong bond that makes polymer have higher ability to absorb energy .in the present study there was a good improvement of shore hardness of HDPE /PP blends through the addition of ABS, From the result obtained for binary blend of HDPE/PP (70%HDPE contain) the shore hardness was (65). The hardness of the material is somewhat lower than that of the ternary blend of HDPE/PP/ABS at 6%ABS and 70%HDPE and this may be due to fact that the advantage of ABS is that this material combines the strength and rigidity of the acrylonitrile and styrene polymers with the toughness of the polybutadiene rubber(17). The most amazing mechanical properties of ABS are resistance and toughness.

3.2 Bending Test: -

Modulus measures the resistance of a material to elastic deformation.For linear elastic materials the stress ζ is related to the strain ε by young's modulus E (Hooke's law).

$$\zeta = E\ \varepsilon \quad \ldots.\ \ldots\ldots.(1)$$

$$E = \left(\frac{mass}{deflection}\right)\left(\frac{gL3}{48I}\right) \text{ ----- } (2)$$

$$I = \frac{DB3}{12} \text{ --------- } (3)$$

Where: I = Engineering bending momentum

D= Width of samples (mm)

B = Thickness of samples (mm)

G = Gravity Force (m/sec^2)

L = Sample length (mm)

Mass/deflection: is the slope of linear part of mass deflection curve obtained [18].

Hooke's law: The amount of change in the shape of an elastic body is directly proportional to the applied force, provided the elastic limit is not exceeded. At different bending load, modulus of elasticity is calculated by using the following equations:

Figure (2) show the modulus of elasticity of HDPE/PP/ABS blends as function HDPE content. From this figure, it can be seen that there is a pronounced effect of addition of %HDPE at on the modules of elasticity of the material. Increasing % HDPE content leads to increase in the modulus of elasticity. This may be done to fact that the increase of binder force between the molecules of the matrix .That is due to miscible blend and compatibility between these types of polymers, because of the linear chain of PP and HDPE can be bonded with each other by physical forces [19]. This implies a decrease in the strain rate. From the above-mentioned results, it is clear that the ternary blend HDPE/PP/ABS has higher modulus of elasticity than that of binary blend HDPE/ PP .

3.3 Impact strength Test:-

The ability of material to with stand impact loading condition is quantified by an impact test method which determines a materials ability to absorb energy over a short period of time. In general the more brittle the material the lower the impact strength . Toughness is defined as the ability of the polymer to absorb applied energy [14].

Figure 3 shows the impact strength of HDPE/PP/ABS blends as a function of HDPE content. From this figure it is clearly seen, that the increasing of the HDPE content causes an increase in the impact strength, The maximum value pass through maxima at 70% HDPE. Also from the result obtained for binary blend of HDPE/PP (0.057 J/mm2) and without addition ABS at 70%HDPE the impact strength of the material is somewhat lower than that of the ternary blend of HDPE/PP/ABS at 6%ABS and 70%HDPE, implying a toughening role of ABS, that ABS contains three monomeric building blocks acrylonitrile, butadiene and styrene. Each of the three major components brings a different set of useful properties to the finished product. Acrylonitrile brings chemical resistance and heat stability .Butadiene provides impact resistance and toughness. Styrene ensures rigidity and processing [15].

4. Conclusions

1- Pure HDPE gives higher values of shore hardness than HDPE/PP/ABS blends.
2- The addition of HDPE was found to improve the impact strength of the polymeric matrix.
3- The modulus of elasticity of HDPE/PP/ABS blends increases with increase of wt % HDPE
4- Addition of acrylonitril–butadiene–styrene (6wt %) improved the mechanical properties for HDPE / PP blend.

References

1. Jang B. Z. Uhlmann, D. R., and J. B. Vander Sande," Rubber Chem. Technol". Vol. 57, 291, (1978).

2 Chen. C. C. and White J. L., "Polym. Eng. Sci." Vol. 33, 923, (1993).

3.Charef H.,SabueT. and GabrielG. ,"Micro-and Nanostructured Multiphase Polymer Blend System" , CRC Press, New York ,(2005).

4. Robertson R. and Paul D.,"Applied Polym. Sci.", vol.17, 2579 - 2595, (1973).

5. Oscar F., Noel III, JamesF. and Carley , " Polym. Eng. Sci. ", vol.15, 117 – 126, (1975).

6. Ezio M., Mariano P., Maurizio A., RobertoG.and Giuseppe, R., "Micromoleculer Chemistry .", Vol.181, 957 - 967, (1980).

7. David A. B., Michael J. R. and Norman G. S., "Macromolecules Chemistry." , Vol.182 , 1271 - 1282 , (1981).

8. Chang S.and Sung C. ,"Applied Polym. Sci.", Vol. 37, 317 - 334, (1989).

9. Mitsuyoshi F.and Youtoku K. ,"Applied Polym. Sci.", Vol.42, 481 – 488, (1991).

10. Zeng, M., Dan C.and Guie S., "Journal of Polym. Research", Vol.2, 257-261 (1995).

11. Tai CM, Li RKY, Ng CN, " Polym. Testing",vol.19 ,143,(2000).

12. Aimeline, C., Françoise, F. , Jean, G., Mohamed., Henri, W. , "Applied Polym. Sci. ", Vol.95, 312 – 320, (2004).

13. Man, H., Byung, K., "Polym. Eng. Sci. ", vol.44, 1858 - 1865, (2004).

14. Annual book of ASTM,Section8,Vol.08.01Plastic,"ASTM. ", Philadelphia,1989.

15. ASTM ,D 790 M,P.(290-297), (1986).

16. Donald, R., Askelane, W., and Phule, P.P., "The Science Engineering of Materials", 4th edition, John Wiley, New York, (2003).

17. The Loctite design guide for bonding plastics, "ABS- Acrylonitrile Butadiene styrene ",27 October, 2006, available online at:www.loctite. http://www.anl.gov/AvailableTechnologies/.html

18. http://www.owenscorning.com/owens / composites/co.pdf.

19. Harper C.A., "Handbook of plastic and elastomers", McGraw-Hill, New York, pp 1-62, 2-42, 3-1, (1995).

20. Shah, V. "Handbook of Plastic Testing Technology ", John Wiely and Sons, New York, (1998).

21. Charles, H.A., "Modern Plastics Encyclopedia", McGraw – Hill, Inc., New York, (1990).

Table (1) HDPE/PP/ABS blends composition and temperature profiles of single screw extruder

Polymer	Temperature(^{o}C)				Screw speed (RPM)
	Zone 1	Zone 2	Zone 3	Zone 4	
HDPE/PP	150	170	220	200	30
HDPE/PP/ABS	155	190	250	220	30

Table (2) Weight percent of HDPE/PP/ABS.

Formulate no	HDPE%	PP%	ABS%
1	40	54	6
2	50	44	6
3	60	34	6
4	70	24	6
5	70	30	0

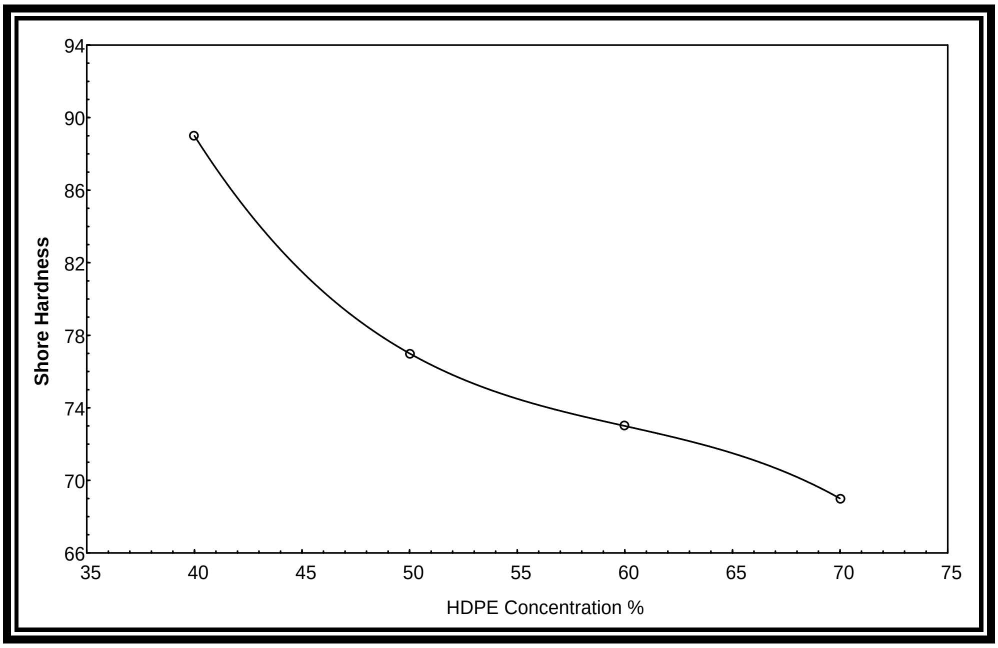
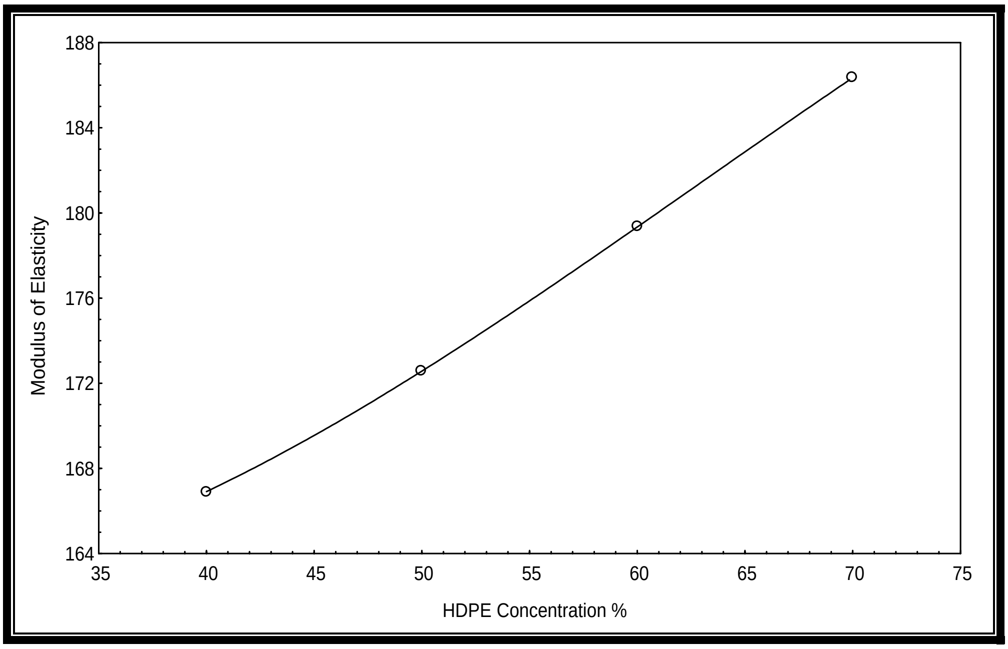


Fig (1)The Shore hardness of HDPE/PP/ABS as a function of %HDPE content



Fig(2)The modulus of elasticity of HDPE/PP/ABS as a function of %HDPE content

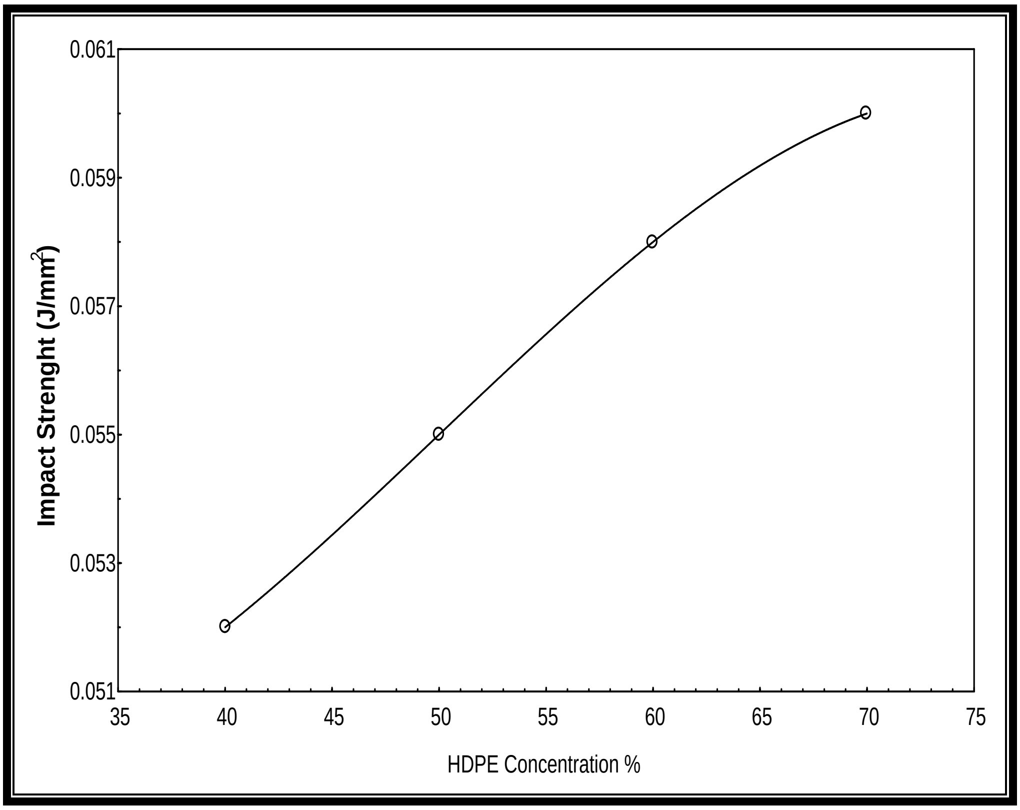


Figure (3) The Impact strength of HDPE/PP/ABS as a function of %HDPE content