Physical behavior of polypropylene/low density polyethylene blends

by

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Abstract:

Blends of polypropylene (PP) and low-density polyethylene (LDPE) may contribute to make recycling more economically attractive. The aim of this work was to make LDPE /PP blends (0/100, 10/90, 25/75, 50/50 w/w) via injection molding carried out under 170 ^{o} C injection temperatures and to evaluate their physical properties including :(Shore D hardness, Density, Tensile strength , elongate to break , Fracture toughness ,impact strength, weight gain and thermal conductivity properties . The blend behavior dependent on its composition, especially regarding elongation at break and the presence of necking . The optimum sample was (10:90 w/w) (PP/LDPE).

This sample has the optimum elongation to break, optimum fracture toughness, optimum thermal conductivity, and other properties.

Increasing of PP contents over the optimum value leads to decreasing of the properties of blend.

Weight gain of these samples increasing with increasing of the Immersion time in oil and benzene liquid but the sample not affected when exposed water.

Key words: immiscible blends, PP/LDPE blend, physical properties, Low-density polyethylene; Polypropylene; Blends; Tensile and impact

الخلاصه :

تم تحضير خليط من البولي اثلين الواطئ الكثافة والبولي بروبلين لعمل خليط بوليميري اقل كلفة من الناحية الاقتصادية. الهدف من البحث هو عمل خليط بوليميري من البولي اثيلين بطريقة القولبة والبولي بروبلين الواطي الكثافة بنسب (0/100, 10/90, 25/75, 50/50 w/w) بدرجه حراره ١٧٠ درجه مئويه بطريقة القولبة بالبثق لغرض دراسة الخواص الفيزيائية المتضمنة(الاستطالة

صلاده شور ، الكثافة ، مقاومة الشد ، الزياده بالوزن والتوصيلية الحرارية) ، افضل عينة كانت بنسبه (١٠ : ٩٠) (بولي بروبلين : بولي اثيلين) واطئي الكثافة : اظهرت النتائج ان العينة التي تحتوي ١٠% بولي بروبلين تظهر زيادة في جميع الخواص وبزياة نسبه البولي بروبلين يؤدي الى تدني الخواص الفيزيائية للخليط .الزيادة في وزن العينات اظهرت زيادة في مع زيادة زمن الغمر في النفط والبنزين فيما اظهرت النتائج ان الماء لايؤثر على الخليط البوليميري .

1. Introduction:

As the economy achieves global status, many factors regarding the competitiveness of a nation come under investigation. More recently, together with important areas such as technology advancement and technology transfer, issues related to sustainable development and environment preservation are receiving increasing attention from the world community.[1]

Mixing of the polymers especially polyolefin leads to production of materials with positive properties omitting more expensive stages of the new polymer synthesis.[2]

One of the most extensively studied polyolefin are polyethylene and isotactic polypropylene. Many papers are devoted to investigations of the polyethylene-polypropylene blends [3].

Because of their large usage polyolefin are likely to be major components of any source of scrap plastics which might be candidate for this scheme of reuse .[4]

When polypropylene is added to the polyethylene, there is a significant reduction in impact strength, with partial sample fracture for the 25%LDPE content blend. Further PP addition makes the blend behavior change from ductile to brittle.[5]

Blending of PP and different PEs largely depends on the miscibility or immiscibility of the two components. PP and LDPE or HDPE are generally considered immiscible in the whole composition range and shows a remarkable phase separation during cooling/crystallization .[6]

The incompatibility between LDPE and PP has already been reported by various authors [7,8], following microscopy and calorimetric studies. In

LDPE rich blends, a heterogeneous PP dispersion in the LDPE matrix produces two phases in the melt. The low interfacial adhesion between the phases is responsible for a decrease in mechanical properties especially related to its morphology, including impact strength, strain at break and ductile to brittle transition. According to Shanks [9], the immiscibility between the phases makes the rule of mixtures ineffective in predicting some properties of interest.

2.Materials and methods

Polypropylene (H301-Braskem) and low density polyethylene (BC 818-Braskem) were used. The specific gravity of the PP is 0.905 and that of the LDPE is 0.918 g/cm^3, with melt flow index of 10.0 and 7.5 g/10 min, respectively. Pure PP, pure LDPE and their blends were processed in an injection-molding machine with various LDPE/ PP weight contents, namely 100/0, 10/90, 75/25, 50/50,as in table 1.

Table 1. blended that prepared at this search

Sample name	LDPE content	PP. content
PP0	100%	0
PP10	90%	10%
PP25	75%	25%
PP50	50%	50%

, these blends was processed at 170 ^{o}C injection temperature.
In this work, the evaluation of tensile and impact properties of PP/LDPE blends was carried out to investigate the composition range for better mechanical performance and also to define the impact of PE addition on PP for composition adjustment of blends used in a commercial recycling unit in Almirante Tamandare´/PR, Brazil.
machine (Model DL10000), in general accordance with ASTM D638. Data of tensile strength, fracture toughness and elongation at break were obtained in tests carried out at a crosshead speed of 5 mm/min. For low elongations, an EMIC extensometer having a gage length of 25 mm was used. Impact tests were performed on a PANTEC equipment (model PW-

4), in general accordance with ASTM D256. Between 10 and 20 measurements were taken for each experimental condition, and the reported results include the mean values and their standard deviations.
Shore D hardness was measured by Shore (Durometer) Hardness tester Meter 0-100HD, thermal conductivity was measured by Lees' disc method. And the density of samples was measured according to Archimedes' law.

3. Results and discussion

3.1 Density of blends

Fig (1) shows the relationship between the density of samples and the PP content, we notice that the density of blends decreasing with increasing of the PP content, this is because the resulting sample carries properties located between the properties of its components and polypropylene have a density less than the density of polyethylene which leads to decrease the density PP/LDPE blends with increasing of PP content. [10]

3.2 Shore D Hardness:

Shore D results confirmed these facts since PP has higher hardness value than the other named polymers. Furthermore it noticed that shore D values (LDPE : PP) blends increased as the weight ratio of PP increased as a result to the nature of PP which is stronger and stiff and more rigid than LDPE . From fig (2) curves it has been noticed that the highest value have been recorded at 50:50 (HDPE : PP) blend which were (60.3). [11]

3.3 Tensile Test

The results of tensile tests for the blends of LDPE : PP were presented in the following Figure 3. The results show pure LDPE has higher tensile strength properties than the other types of polymer blends components and it decreases with increasing of PP content, that related to PP have a rigid shortly methyl group attached to every second carbon atom of the polymer main chain, which restricts rotation of the chain producing a stronger but less flexible material .[12]

By increasing of weight percentages of PP from 10% to 50% there will be change in the behavior from soft and tough with low percentage of PP to hard and tough with high percentage of PP in the blend.

3.4 Elongation to Break:

Fig. 4. indicate to the PP10% blend has the highest elongation to break then it decreases with increasing of with increasing PP content due to the fact that PP is strong as compared LDPE.

3.5 Fracture Toughness and Impact Strength:

The Impact strength and fracture toughness are often the deciding factor in material selection because impact test measures the ability of polymer to withstand the load imposed upon being struck by an object at high velocity, thus it is a measure of energy required to propagate a crack cross the specimen, therefore the impact properties of these samples are especially important.

From Figures 5 and 6 which were shown the effect of blend ratio on impact strength and fracture toughness respectively for (LDPE : PP) polymer blends, from Figure 5 that there are a depression in impact strength these value for LDPE when mixed with PP, the fracture toughness and impact strength decreased with increasing of weight percentage of PP and that belongs to a rigid shortly methyl group attached to every second carbon atom in the linear molecular chain of PP and this cause PP has relatively low impact strength for this the optimum value of impact strength and fracture toughness it is for (PP10%) , and the lowest value for (PP 50%), [12,13]

The optimum value of fracture toughness for PP.10% also because it has highest elongation to break this leads to increase of the absorption energy of sample before it's break.

3.6 Thermal Conductivity:

Results of thermal conductivity shows there is an decreasing of value for PP10% compare with pure LDPE, this value decreases from 0.205 W/m2.K to 0.013 W/m2.K

This is very important to development thermal properties of PP:LDPE blends. [14]

The thermal conductivity of immiscible blends according to the rule of mixture, and this leads to decreasing of thermal conductivity value of PP10% to o.013 because the PP has lower thermal conductivity than LDPE. In immiscible blends the phonon scattering at the interface between two components seems to contribute less to the thermal conduction or by other mean the phonon vibration frequency will be quickened to make the collision possibility increase, so the mean free path decrease rapidly, which leads to the rapid decrease of its thermal conductivity.[15]

Table 2. shows the properties of the optimum blends PP10%

Table 2. Properties of the optimum sample (LDPE90%+P.P10%)

Density gm/cm^3	**0.9461**
Shore D	**52.7**
Tensile strength Mpa	**14**
Elongation to break	**0.76**
Impact strength J/mm^2	**0.04 without failed**
Fracture toughness J/m^3	**9.03**
Thermal conductivity W/m^2.K	**0.013**

Then for the optimum sample PP10% we measured the thermal conductivity and the weight gain versus immersion in different liquids (oil, benzene, and water) as following .

3.7 weight gain

Weight gain results show there are an increasing of it with increasing of the time of immersion in oil and benzene liquids, this because these liquids react with blend, depending on where the molecules of the polymers are able to create secondary bond with the solution so the swelling occurs [16]

While water immersion results there is no any effected , of the weight gain with increasing of immersion time , this because there is no react between the polymer blends and water and there is no swelling in polymer chain as in fig 7.

4. Conclusions:

1. (10-90)% blending ratio (PP/ LDPE) showed better mechanical, physical and chemical properties .
2. oil has lower effected on the properties of blend than the benzene, while the water was not effecting on the blend properties for 12. week immersion.

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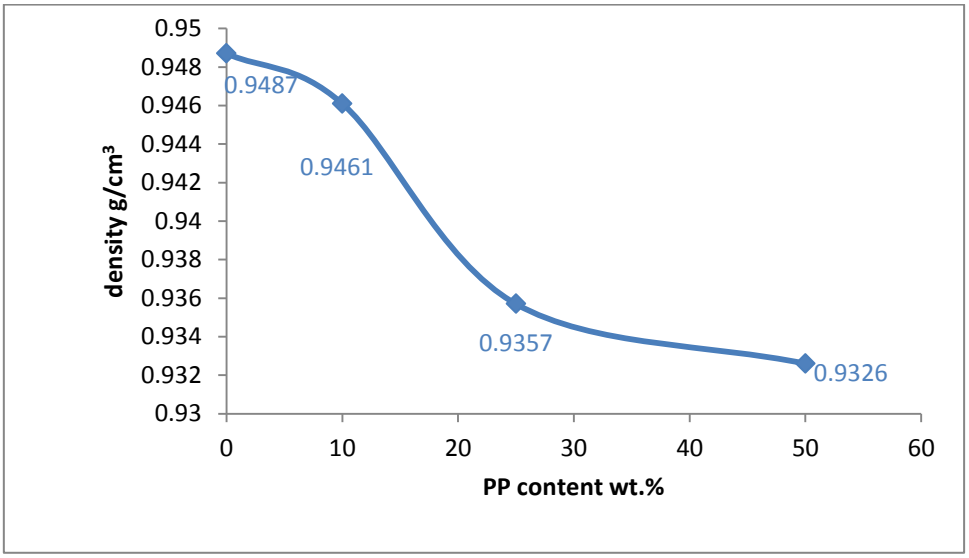

Fig 1. relationship between the density of blends (PP+LDPE) AND P.P content wt.%

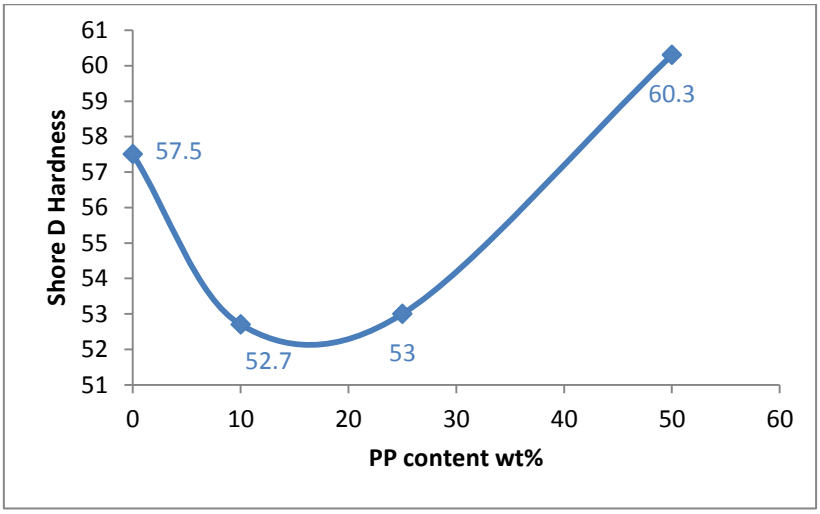

fig 2. relationship between the Shore D Hardness and PP content of immiscible blends (LDPE+PP

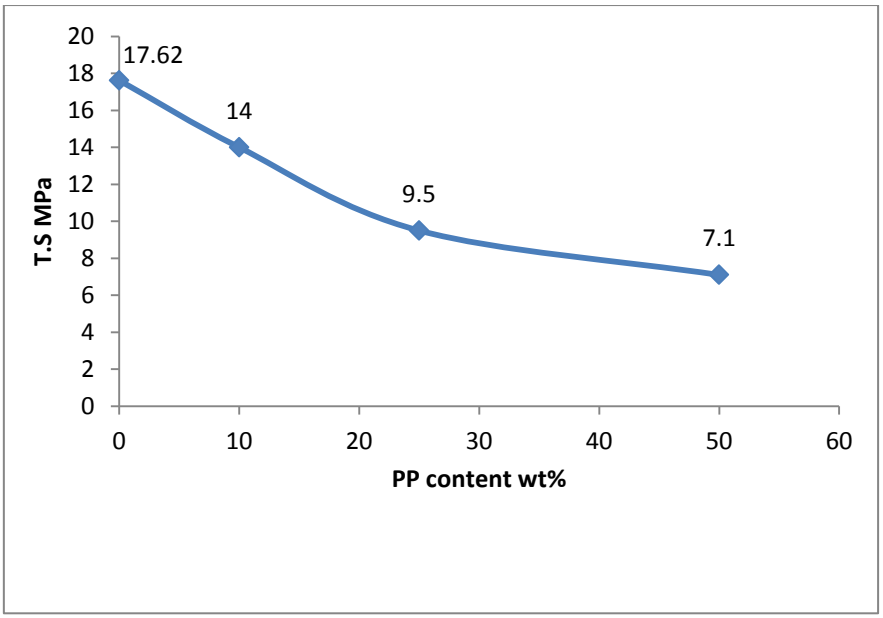

fig 3. relationship between P.P content and tensile strength of immiscible blends (P.P+LDPE)

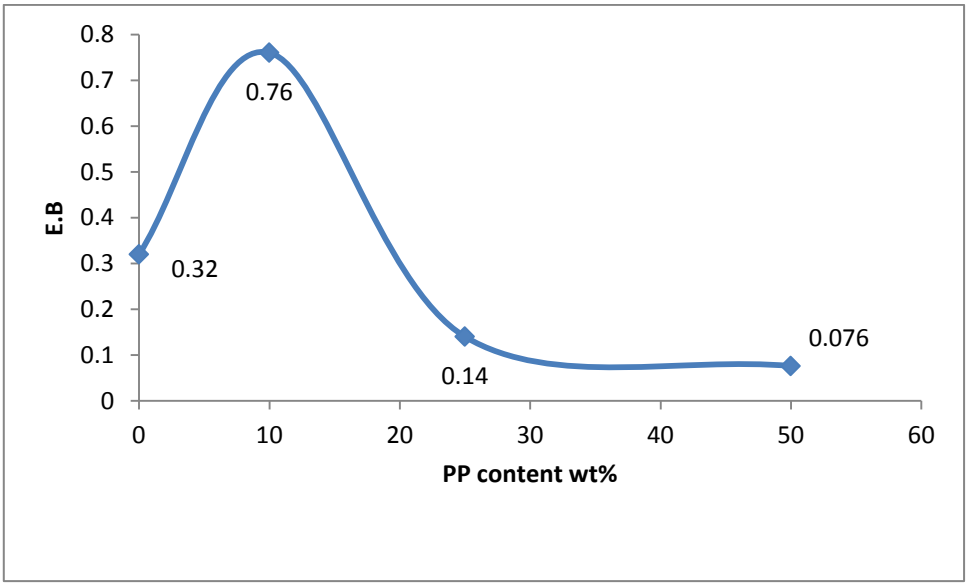

Fig 4. relationship between the P.P content and elongation at breck of immiscible blends (P.P +LDPE)

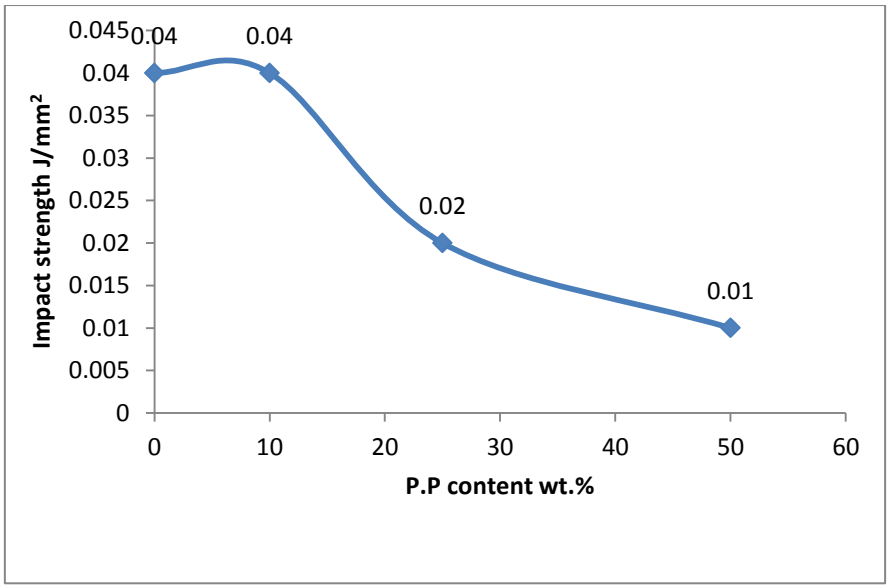

fig 5. relationship between the impact strength and P.P content of immiscible blends (LDPE+PP)

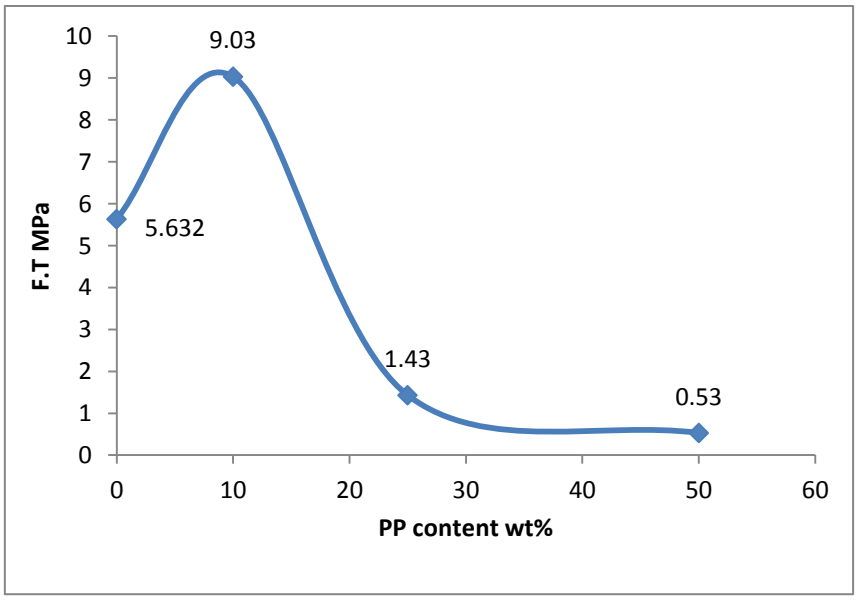

fig 6.relationshipe between the fracture toughness and P.P content of immiscible blends (P.P+LDPE)

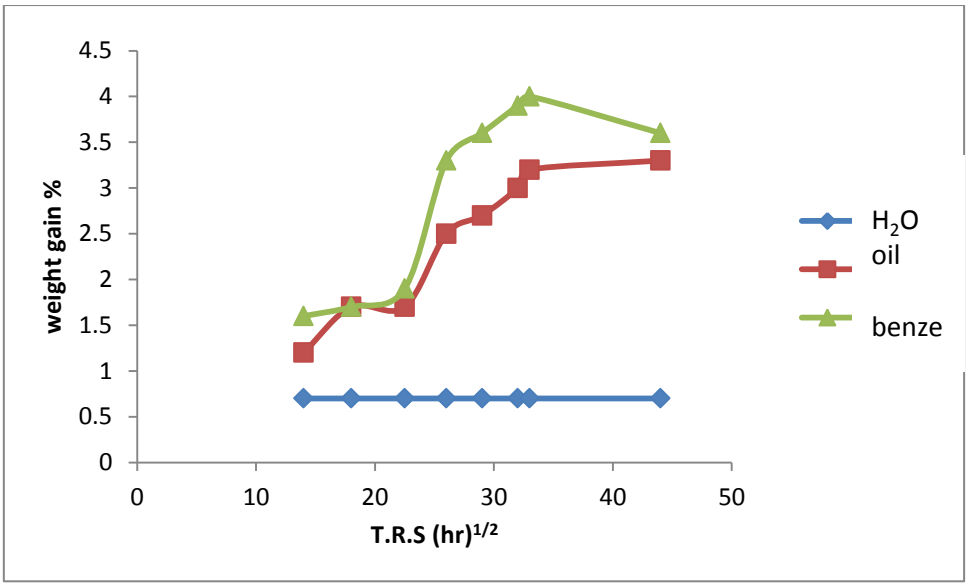

fig 7. relationship between the time immersion and the weight gain of the optimum sample PP10% in different liquids