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MECHANICAL AND RHEOLOGICAL PROPERTIES OF POLYPROPYLENE (PP)/LINEAR LOW DENSITY POLYETHYLENE (LLDPE) BLEND FILLED WITH TALC AND CALCIUM CARBONATE COMPOSITIONS

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ABSTRACT

The mechanical, rheological properties and density of polypropylene (PP) and linear low density polyethylene (LLDPE) blend filled with talc and calcium carbonates were studied. PP/LLDPE (70/30) was selected and investigated at different four fractions of talc and calcium carbonate. The mechanical properties such as impact resistance and hardness were investigated. The rheological properties such as melt flow index (MFI) and melt density were evaluated. In addition, density test have been determined**.** The results indicated that incorporate talc and calcium carbonate led to increase the hardness, MFI and melt density while decreased the impact resistance PP/LLDPE blend. It was obtained that increase talc and calcium carbonate content into PP/LLDPE blends will increase the density. Taking into consideration, it was concluded that, the optimum composition provided the good mechanical, rheological properties and density is PP/LLDPE/Talc/Calcium carbonate (42/18/20/20) wt%.
Keywords: PP/LLDPE; Talc; Calcium carbonet ; Mechanical; Rheological properties.

INTRODUCTION

The interest in polypropylene(PP) and polyethylene (PE) is specifically due to the fact that both these polymers are widely used as important engineering materials in the automotive, electrical appliances and packaging industries due to their excellent properties such as rigidity and stiffness, oil resistance and their thermal stability [1]. Apart from these good properties that polypropylene has, its applications are often limited due to its low impact strength and Young's modulus, particularly at low and high temperature loading conditions. These polypropylene drawbacks can be considerably improved by blending polypropylene with other polymers [2-3].Generally there are two ways used to improve polymer properties are polymer blending and the use of filler to form polymer composites.These two methods were extensively, but separately used. The blending of two or more polymers is a cheaper and more effective alternative, not only for the development of polymers with new properties, but also for recycling of greener materials[6].Polypropylene/polyethylene(PP/PE) are amongst polymer blends that were studied by various researchers [6]. Three different types of PE, namely low-density polyethylene (LDPE), high density polyethylene (HDPE), and linear low-density polyethylene (LLDPE) were used to modify the physical and mechanical behaviour of polypropylene by forming physical blends [6-9]. Blending of polypropylene and different polyethylene's largely depends on the miscibility or immiscibility of the two components. Polypropylene, LDPE or HDPE are generally considered immiscible in the whole composition range and shows a remarkable phase separation during cooling/crystallization [1]. Studies dealing with polymer blends reinforced with rigid fillers to give three-phase polymer composites are still fairly new. In cases where these studies were done, synthetic and mineral fibers and commonly used are talc, calcium carbonate, kaolin, magnesium carbonate, silica, alumina, titanium dioxide and mica carbonate were used as fillers [10-11].

MATERIALS AND METHODS

2.1 Materials specification

2.1.1 Polypropylene (PP) Materials:

Supplied by Khartoum Petrochemical Company (KPC, Sudan), in powder shown in table1.

Table1. Specification of KPC-Polypropylene (PP)

Trade name	PP-114
Density	0.914 g·cm^{-3}
Melting point	230°C
Melt flow index (MFI)	30g/10min (230°C, 2.16 kg).
Tensile stress at Yield	27.5MPa
Impact Modulus	950MPa

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Izod impact resistance	20 J/m
Heat deflection temperature	71°C

2.1.2 Linear low density polyethylene (LLDPE):
Supplied by SABIC (Saudi Arabia) in pellet shown in table2.

Table2. Specification of SABIC-LLDPE

Trade name	LLDPE-218N
Density	0.918 g·cm^{-3}
Melting point	190°C
Melt flow index (MFI)	2g/10 min (190°C, 2.16 kg).
Tensile stress at Yield	12MPa
Impact Modulus	260MPa
Vicat Softening Point	98°C

2.2 Methods (Preparation of the compositions):
In the experimental study, four different talc and calcium carbonate concentrations were added to PP/LLDPE (70/30) to produce composites make up a total of 1kg. The samples were prepared in injection moulding machine at 180°C - 220°C. Then the following were carried out : impact resistance, hardness, MFI and melt. In addition density test has been determined. PP/LLDPE filled with talc and calcium carbonate to produce PP/LLDPE blend composition is shown in table 1.

Table3. Composition percentage of PP/LLDPE blends filled with talc and calcium carbonate

Exp No	PP (Wt %)	LLDPE (Wt %)	Talc (Wt %)	CaCo3 (Wt %)
1	70	30	-	-
2	56	24	20	-
3	56	24	-	20
4	56	24	10	10
5	42	18	20	20

2.21 Impact test (Izod):
Izod impact strength values of the composition were evaluated with a Resil impact test instrument according to the ASTM D256 test procedure at room temperature. Izod impact tests specimens were molded in a size of 12.7 mm (width), 3.2 mm (thickness) and notched width 10.20mm.
2.2.2 Hardness test (Shore D):
The hardness test of the composition was carried out on a Innova testing machine according to the ASTM D 2240 and ISO 868.
2.2.3 Melt flow index (MFI) and Melt density tests:
The melt flow index (MFI) composition were determined by a Shijiazhu Ang Zhong Shi testing machine according ISO 1133:2005 method and facilities of automatic cutting. The die diameter of 2.095mm, charge canister diameter 9.55mm, length 160mm and applied dead mass of 325g.
2.2.4 Density test:
The density test of the composition was carried out on BOROSIL pycnometer (25ml) according to the ASTM D 1505.

RESULTS AND DISCUSSION

3.1 Mechanical properties:
3.1.1 impact test
The impact properties of PP/LLDPE blend and composition are summarized in Table 4 and Figure 1
The impact resistance of PP/LLDPE blend was 30.01J/m. It is clearly seen that the addition 20 wt % of talc to PP/LLDPE has decreased the impact resistance to 20.53 %.

Table4. Impact resistance of PP/LLDPE and composition

Exp no	Notched Width (mm)	Energy (J)	Imact resistance(J/m)
1	10.38	0.0960	30.01
2	10.30	0.0763	23.85
3	10.30	0.0667	20.83
4	10.35	0.673	21.04
5	10.33	0.730	22.80

The addition of 20 wt % calcium carbonate has decreased the impact resistance to 30.59%. It can also be seen that the addition of 10 wt % of talc and calcium carbonate has decreased on the impact resistance to 29.89%. Also 20 wt % of talc and of calcium carbonate has decreased the impact resistance to 24.03%.This result may be related to the effects of LLDPE, talc and calcium carbonate on PP. It is well documented that LLDPE increases the impact strength, while talc and calcium carbonate decreases, especially for higher contents [10-12].

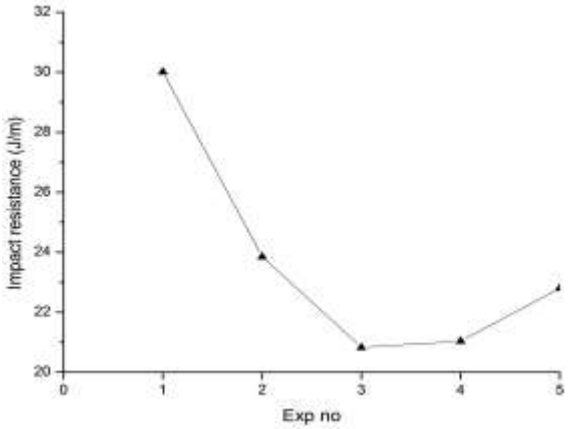

Figure1. Impact resistance of PP/LLDPE and composition

3.1.2 Hardness test (Shore D)
The hardness of PP/LLDPE and composition are shown in Table5 and Figure 2.

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Table5. Hardness of PP/LLDPE and composition

Exp no	Hardness
1	57.4
2	68.1
3	66.2
4	63.1
5	62.5

The hardness of PP/LLDPE blend was 66.2. Addition of 20 wt% of talc to PP/LLDPE has increased the hardness to 18.6%. It can also be seen that the addition of 20 wt % calcium carbonate has increased the hardness to 15.3%. It can also be seen that the addition of 10 wt % of talc and calcium carbonate has increased the hardness to 9.9%. While the addition of 20 wt % of talc and of calcium carbonate has increased hardness to 8.9%. The hardness result may relate to the interaction between PP/LLDPE and talc/calcium carbonate and this restricts the mobility and deformability of the PP/LLDPE [10-12].

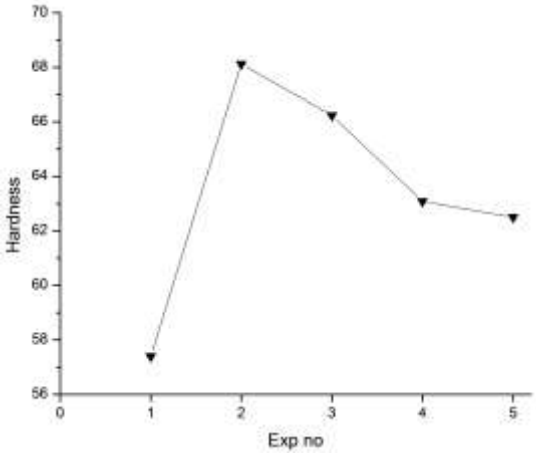

Figure2. Hardness of PP/LLDPE and composition

3.2 Rheological properties:

3.2.1 Melt flow index (MFI) test:

The melt flow index (MFI) test is used to investigate the flow properties of PP/LLDPE and composition are shown in Table 6 and Figure 3.

Table6. MFI of PP/LLDPE and composition

Exp no	MFI (g/10min)
1	23.53
2	43.00
3	35.30
4	31.80
5	26.27

The MFI of PP/LLDPE blend was 23.53g/10min. The result showed addition of 20 wt% of talc to PP/LLDPE increased MFI to 82.75%. It can also be seen that the addition of 20 wt % calcium carbonate increased MFI to 50.02%. It can also be seen that the addition of 10 wt % of talc and calcium carbonate to PP/LLDPE has increased the MFI to 35.15%. Also addition of 20 wt % of talc and of calcium carbonate has increased MFI to 11.64%. This result may be directly related to the undeformability of the filler and its lack of contribution to the flow [10-12].

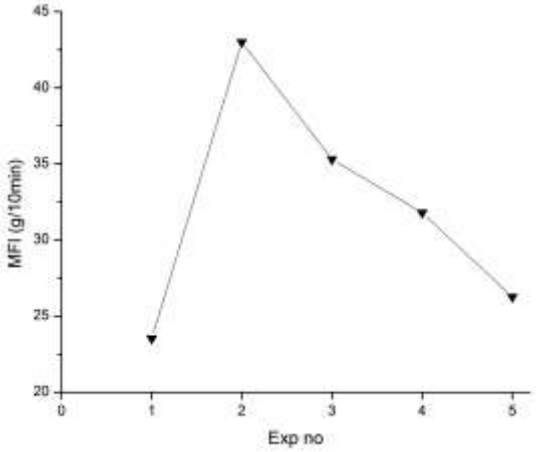

Figure3. MFI of PP/LLDPE and composition

3.2.2 Melt density test

The melt density test of PP/LLDPE and composition are shown in Table 7 and Figure 4.

Table7. The melt density of PP/LLDPE and composition

Exp no	The Melt Density (g/cm^3)
1	0.704
2	0.815
3	0.831
4	0.879
5	0.866

The melt density of PP/LLDPE blend was 0.705g/cm3. The result showed addition of 20 wt% of talc to PP/LLDPE has increased melt density to 15.77%. It can also be seen that the addition of 20 wt % calcium carbonate to PP/LLDPE increased melt density to 18.04%. It can also be seen that the addition of 10 wt % of talc and calcium carbonate to PP/LLDPE increased the melt density to 24.86%. While the addition of 20 wt % of talc and of calcium carbonate to PP/LLDPE has increased melt density to 23.01%.

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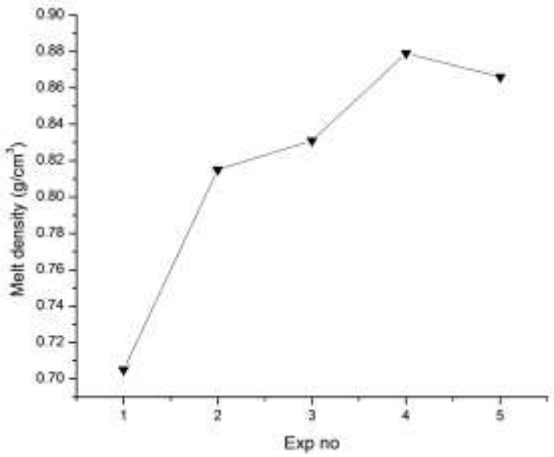

Figure4. The Melt density of PP/LLDPE and composition

This result may be directly related to the undeformability of the filler and its lack of contribution to the flow [10-12].

3.3 Density test

The density test is used to investigate the flow properties of PP/LLDPE and composition are shown in Table 8 and Figure 5.

Table8. The density of PP/LLDPE and composition

Exp no	Density (kg/m^3)
1	0.782
2	0.934
3	0.911
4	0.951
5	1.040

The density of PP/LLDPE blend was 0.782g/cm^3. The result showed addition of 20 wt% of talc to PP/LLDPE (56/24) increased density to 17.63%. It can also be seen that the addition of 20 wt % calcium carbonate has increased density to 14.74%. It can also be seen that the addition of 10 wt % of talc and calcium carbonate has increased the density to 19.77%. While the addition of 20 wt % of talc and of calcium carbonate has increased density s to 30.98%. This result may be related to the effects of LLDPE, talc and calcium carbonate on PP matrix. LLDPE decreases the density, while talc and calcium carbonate increases, especially for higher contents.

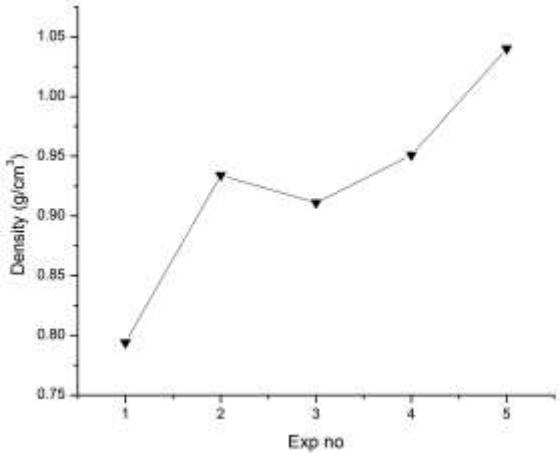

Figure5. The density of PP/LLDPE and composition

CONCLUSION

The compositions of PP/LLDPE (70/30) with different percentage of talc and calcium carbonate fillers were prepared. The work obtained incorporate talc and calcium carbonate as fillers on PP/LLDPE blend led to increase the hardness, MFI and melt density. While decreased the impact resistance of PP/LLDPE blend. The work obtained increase the fillers content (talc and calcium carbonate) into PP/LLDPE blends has increased the density. It was concluded that, the optimum composition provided the good mechanical, rheological properties and density is PP/LLDPE/Talc/Calcium carbonate (42/18/20/20) wt%.

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