

Chapter One:

Introduction

1.1 Introduction:

Plastics have become quite important and widely used materials in daily life and industry for the last forty years. It would be difficult to imagine our modern world without plastics. Today they are an integral part of everyone's lifestyle with applications varying from common place domestic articles to sophisticated scientific and medical instruments. The term plastic refers to a family of materials which includes nylon, polyethylene and PTFE just as zinc, aluminum and steel fall within the family of metals but polymer family has properties not available in any other family that make it more applicable materials.

One of the reasons for the great popularity of plastics in a wide variety of industrial applications is due to the tremendous range of properties exhibited by plastics and their ease of processing. A new approach to the science and technology of polymer blends has emerged recently. These polymeric materials must perform under strenuous mechanical, chemical, thermal and electrical conditions imposed by the requirements of a specific application. Polymers are distinct of their structure consists of very long chain-like molecules. The good designer will recognize to select the most appropriate material and grade on the basis of processability, toughness, chemical resistance, etc[1-2].

It is noteworthy that the polymer blend segment of the plastics industry increases at a rate about three times higher than the whole. Polymers are classified as either natural that resulted from natural biosynthesis, or synthetic. The natural (polysaccharides, proteins, nucleic acids, natural rubbers, cellulose, lignin, etc.) have been used for tens of thousands of years. In Egypt the musical string instruments, papyrus for writing, and styrene [in a tree balsam] for embalming were used. For millennia shellac has been used in Indian turnery The natural rubber was used by Olmecs at least 3000 years ago The term synthetic polymer refers equally well to linear, saturated macromolecules (i.e., thermoplastics), to unsaturated polymers (i.e., rubbers), or to any substance based on crosslinkable monomers, macromers, or pre-polymers (i.e., thermosets)[3].

Development of new material with a broader application is possible by blending polymers, giving more enhanced properties than individual polymer. Producing new materials by blending two homopolymers is economically acceptable also from an ecological view. PP and PE blends have been studied for many years. There have been many discussions about their miscibility [4].

1.2 Objective of Research:

The goal of this research is:

- To make blend that Improvemes impact property for PP by mixing with LLDPE.
- Analysis of data of dynamic mechanical properties and impact properties at various compositions of the blend.

1.3 Research Methodology:

Since many materials (especially thermoplastics) exhibit lower impact strength at reduced temperatures, it is sometimes appropriate to test materials at temperatures that simulate the intended end use environment. Linear low-density polyethylene (LLDPE) was compounded with polypropylene (PP) to improve its impact strength, flexural strength, heat deflection temperature (HDT) and melt flow index (MFI). Tightly integrated with excel to give graphs of relationship between LLDPE percentage and the impact strength, flexural strength, heat deflection temperature (HDT) and melt flow index (MFI).

The sequence, is composed of the five chapters: (chapter 1),.intruduction of research, objective of research, Research Methodology, Boundaries (chapter 2).. Introduction, Polyethylene, Polypropylene, Mechanical property of Polypropylene, (chapter 3) . Introduction, Blending, Mechanical Tests, condition, samples, Instruments and result. (chapter 4).. Introduction, result, discussion and cost estimation (chapter 5). Conclusion and Bibliography

1.4 Boundaries

Temporal boundaries: 2013- 2014

Spatial boundaries:

We invested much time outside their regular duties, collecting the material and setting it into uniform text. The sample preparation and tests (Impact, Heat deflection Temperature and Flexural) had done in Khartoum Petrochemicals Company (KPC) - tests Lab, the Melt Flow Index test done in Sudan University of Sciences & Technology- college of Engineering- Department of plastic engineering.

Chapter two

Literature review

2-1. Introduction:

Development of new material with a broader application is possible by blending polymers, giving more enhanced properties than individual polymer. Producing new materials by blending two homopolymers is economically acceptable also from an ecological view. PP and polyethylene blends have been studied for many years. There have been many discussions about their miscibility [4].

Blending of chemically different polymers is an important tool in industrial production for tailoring products with optimized material properties. Performance of polymer blends depends on the properties of polymeric components, as well as how they are arranged in space. One of the most basic questions in blends is whether or not the two polymers are miscible or exist as a single phase, most blends of high molecular weight polymers exist as two-phase materials. The morphology of the phases is of great importance in this manner. A variety of morphologies exist such as dispersed spheres of one polymer in another, lamellar structures, and co-continuous phases (Kukaleva, Cser, Jollands, & Kosior, 2000). Blends of polypropylene (PP) and polyethylene (PE) have become a subject of great economic and research interest because of the need to improve the processing and properties of PP as an engineering plastic due to its relatively low impact strength especially at low temperature and poor environmental stress cracking resistance. Blends of PP with linear low density polyethylene (LLDPE), very low density polyethylene (VLDPE) and ultra low density polyethylene (ULDPE) have been reported to be miscible, partially miscible or immiscible (Li, Shanks, & Long, 2001, 2003; Utracki, 2003). [1].

2.2 Polyethylene:

Ethylene has been used in chemical reactions for as long as it has been in existence. It is a very useful and reactive substance due to its double bond.



Figure 2.2 Polyethylene polymer

It was not until 1898 however that the first experiments to create long chain molecules with ethylene had commenced. The first reactions however had several problems. First, solid polyethylene had not been able to be produced. That is all the products of these early reactions were waxes and greases. The non-solid polyethylene polymers had little use at the time. It wasn't until 1933 when the first solid polyethylene polymer had been produced. Two scientists working for the Imperial Chemical Company had made this discovery. These scientists, E. W. Fawcett and R. O. Gibson, had produced this solid polymer while experimenting with pure ethylene gas at extremely high pressure and temperature. The ICI didn't wait long before obtaining a patent for this new material and began to market it.

The first applications of this early polyethylene polymer were for use as coatings. The primary coating that the ICI marketed polyethylene for was as insulation on electrical wires. The Telegraph Construction Maintenance Company had invested a lot in order to coat their submarine cables with this new polymer. It was about this time when the British Military had begun to use this polymer in the coating of their high frequency cabling and wires. This allowed the British to make great technological strides in the radar field. History has stated that it was because of the polyethylene polymer used here that the British had possessed the best radar capabilities in the world. It was also about this time when work commenced on discovering ways of lowering the reaction conditions to produce polyethylene polymers. A polyethylene polymerization mechanism was the reaction conditions were accomplished in 1951 by Karl Ziegler. Ziegler was able to produce the solid polyethylene polymer at low pressures and temperatures by employing a catalyst. Testing on Ziegler's polyethylene polymer had shown that it had a larger density than the original high-pressure polyethylene process. It was after this discovery that characterization of polyethylene polymers were based on their density.

Shortly after Ziegler had discovered HDPE (High Density Polyethylene) another group of researchers working at the Phillips Petroleum Inc. had discovered other catalysts that produced the same results as Ziegler's process. These HDPE polymers were characterized as having fewer branches than those early high-pressure polyethylene polymers (LDPE - Low Density Polyethylene). In 1977 researchers working at Union Carbide Corporation discovered a method to produce a new polyethylene. This new polyethylene was made from monomers other than ethylene gases, and as a result contained few short branches. Because of this property they were termed as LLDPE (Linear Low-Density Polyethylene) Polymers. New Polyethylene polymers are still being developed today. This polymer contains a rich history rooted back more than a century ago.

2.2.1 Controlling the Properties of Polyethylene:

Why would changing the reaction conditions have an effect on the properties of the LDPE polymers? It was in the 1940's when Infrared Spectrum analysis of chemical compounds began to appear as an important method for determination of chemical structure. Polyethylene, as shown above can have different properties depending on the reaction conditions. When the polyethylene polymers were subjected to IR Spectroscopy the results were startling. The results of the testing had shown that the polymer contained a large number of methyl groups in a single molecule. These results are explained because the molecule has many branches of varying length along its backbone chain. The amount of chains and length of the chains are what varies the properties of the polymer. Branching in the polymer must then be a function of pressure. In fact as the reaction pressure is increased the branching in the polymer is decreased [5].

Polyethylene Characterized by stiffness, strength/toughness, resistance to chemicals, moisture, by flexibility, toughness, tear resistance, drop impact resistance. Low seal temperature.

2.2.2 Some application of Polyethylene:

The key to PE stiffness and strength is chain length and crystallinity that give lots of application. PE used in safe to use for food packaging, drinking water pipes, is saving food, grooming and hygienic purposes and thousands of other safe uses in our everyday lives.[6].

2.3- Polypropylene:

Spain, 1954, polypropylene was first produced by Professor Giulio Natta. Natta was able to produce the resin by using catalysts from the polyethylene industry and applying them to propylene gas. The first commercial production began in 1957[7].

The macromolecule of PP contains 10,000 to 20,000 monomer units. The steric arrangement of the methyl groups attached to every second carbon atom in the chain may vary (see Figure 2). If all the methyl groups are on the same side of the winding spiral chain molecule, the product is referred to as isotactic PP. A PP structure where pendant methylene groups are attached to the polymer backbone chain in an alternating manner is known as syndiotactic PP. The structure where pendant groups are located in a random manner on the polymer backbone is the atactic form.

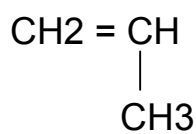
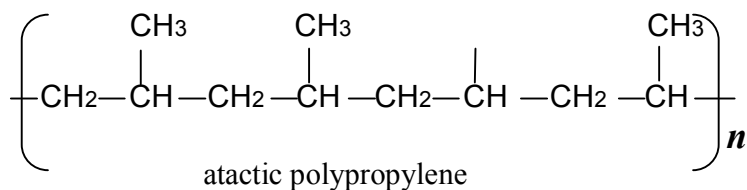
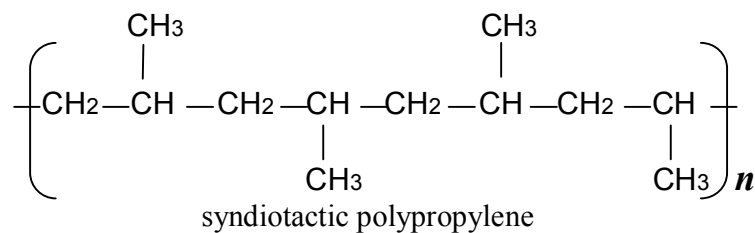
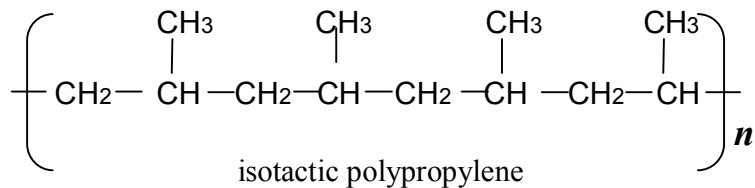


Figure 2.3 Propylene monomer



2.3.1 Advantages of Polypropylene:

PP is very popular as a high-volume commodity plastic. However, it is referred to as a low-cost engineering plastic. Higher stiffness at lower density and resistance to higher temperatures when not subjected to mechanical stress (particularly in comparison to high and low density PE (HDPE and LDPE)) are the key properties. In addition to this, PP offers good fatigue resistance, good chemical resistance, good environmental stress cracking resistance, good detergent resistance, good hardness and contact transparency and ease of machining, together with good processibility by injection moulding and extrusion.

2. 3.2 Disadvantages of Polypropylene:

The major disadvantages of unmodified PP compared with other competitive Thermoplastics it can be seen that PP has significantly higher mould shrinkage, higher thermal expansion and lower impact strength, particularly at sub-ambient temperatures, than HIPS, PVC and ABS. However, PP has lower mould shrinkage and thermal expansion coefficient than HDPE and LDPE. Poor UV resistance and poor oxidative resistance in the presence of certain metals such as copper are other Disadvantages of PP. As any semi-crystalline material, PP also suffers from high creep under sustained load in comparison to an amorphous plastic such as ABS or PVC. Other disadvantages of PP are difficult solvent and adhesive bonding, Poor Flammability, warpage, limited transparency; poor wear properties, unsuitability for frictional applications and poor resistance to gamma radiation. However, most of these disadvantages could be overcome, either completely or to a certain degree, by proper selection of material, sensible design and good processing.

The processing of PP by thermoforming and blow moulding is difficult. Vacuum forming of PP is also difficult. PP is not hazardous to health; however, it can release volatile organic compounds (VOCs) into the surrounding air during high-temperature processing. Workers at the processing plant can be subjected to these VOCs through inhalation or skin contact. Good ventilation using exhaust fans can minimize the exposure. Residual monomer and catalysts present in the resin can increase the toxicity.

2. 3.3 some applications for Polypropylene:

For many years, polypropylene (PP) has been very successfully used for blown film, injection molded, and extrusion applications. Although PP has a most remarkable combination of physical properties so it often use for the manufacture of, Household goods (toys, bottle caps, bottles,), Automotive industry (bumpers, Radiator expansion tanks,) and it has excellent electrical insulation property therefore preferred for the manufacture of electrical application, but because of its high price the PVC replaced .

2.4- Mechanical property of Polypropylene:

The mechanical and thermal properties of PP are dependent on the isotacticity, the molecular weight and its distribution, crystallinity, the type and the amount of comonomer. Additionally, PP is, like other thermoplastics, a viscoelastic material. Consequently its mechanical properties are strongly dependent on time; temperature and stress. The mechanical properties of PP depend on several factors and are strongly influenced by the molecular weight. General observations suggest that an increase in molecular weight, keeping all other structural parameters fixed, leads to a reduction in tensile strength, stiffness, hardness, brittle point but an increase in impact strength. This effect of molecular weight on the properties of PP is contrary to most other well-known plastics [8].

For many years, polypropylene (PP) has been very successfully used for blown film, injection molded, and extrusion applications. Although PP has a most remarkable combination of physical properties, it has poor impact strength especially at low temperature due to the inherently high glass transition temperature (T_g) and high crystallinity [9].

2.4.1- Impact strength for Polypropylene:

The second-order transition temperature of PP homopolymer is $-10\text{ }^{\circ}\text{C}$. This explains the drop in its impact strength at temperatures around $0\text{ }^{\circ}\text{C}$. Several methods are used for measuring the impact strength of PP. However, none of the methods satisfactorily predict performance under conditions of end use. In the Izod or Charpy test, a notch is incorporated in the sample to concentrate stress; this normally leads to brittle failure. Impact strength is reduced as the notch gets sharper.

Consequently, sharp corners in load-bearing sections must be avoided in the design of the article, as a general rule for all the plastics. The impact strength of an article depends on the inherent molecular structure of the grade used and the morphology arising from the processing conditions. Changes in the geometry of an item can have a major effect on its toughness rating. Impact strength increases with the molecular weight but more markedly with comonomer content. The most important way of improving the impact strength of PP is by incorporating a rubbery phase, as in heterophasic copolymers. Toughness increases rapidly with higher rubber content, and its transition from ductile to brittle failure occurs at lower temperatures.

One of the major reasons for the failure of PP artefacts is the brittle failure. This is mainly caused by the incorrect selection the PP grade, particularly the use of PP homopolymer in place of copolymer or use of wrong material at the moulding floor. Infrared microscopy and gel permeation chromatography can quickly identify the source of the problem [8].

2.4.2- Improvement of Impact strength for polypropylene:

Development of new material with a broader application is possible by blending polymers, giving more enhanced properties than individual polymer. Producing new materials by blending two homopolymers is economically acceptable also from an ecological view. In the field of recycling postconsumer waste, economical costs linked to the separating steps could be decreased and, hence, the recycling of plastic waste becomes more profitable [4].

Blending of chemically different polymers is an important tool in industrial production for tailoring products with optimized material properties. Performance of polymer blends depends on the properties of polymeric components, as well as how they are arranged in space. One of the most basic questions in blends is whether or not the two polymers are miscible or exist as a single phase, most blends of high molecular weight polymers exist as two-phase materials. The morphology of the phases is of great importance in this manner. A variety of morphologies exist such as dispersed spheres of one polymer in another, lamellar structures, and co-continuous phases (Kukaleva, Cser, Jollands, & Kosior, 2000).

Blends of polypropylene (PP) and polyethylene (PE) have become a subject of great economic and research interest because of the need to improve the processing and properties of PP as an engineering plastic due to its relatively low impact strength especially at low temperature and poor environmental stress cracking resistance. Blends of PP with linear low density polyethylene (LLDPE), very low density polyethylene (VLDPE) and ultra low density polyethylene (ULDPE) have been reported to be miscible, partially miscible or immiscible (Li, Shanks, & Long, 2001, 2003; Utracki, 2003).

Studies from other groups showed that incompatibly immiscible polymer blends provide synergy of mechanical properties when the processing and compositional parameters are near optimum values (Petronyuk; Priadilova; Levin; Ledneva, & Popov; 2003; Dhoble, Kulshreshtha; Ramaswami; & Zumbunnen, 2005; Chen, Zhon, Cai, Su, & Yang, 2007; Wantinee, Richard, & Jayant, 2007)[1].

The some examples for PP&PE blends were studied by Nina Vranjes Penava¹, Vesna Rekić and Ivona Fiamengo Hura²: Effect of EPDM as a compatibilizer on mechanical properties and morphology of PP/LDPE blends (2012). They concluded the blends of polypropylene (PP) and polyethylene (PE) have become a subject of great economic and research interest because of the need to improve the processing and properties of PP as an engineering plastic due to its relatively low impact strength especially at low temperature and poor environmental stress cracking resistance.

The quite examples for PP & PE is blends of polypropylene (PP) and low-density polyethylene (LDPE) with and without ethylene-propylene-diene (EPDM) terpolymer as a compatibilizer were studied. Mechanical properties were chosen to estimate the compatibilization efficiency of EPDM. The interactions between phases were valued through glass transition shifts in dynamic mechanical spectra, and morphology of the blends was obtained using scanning electron microscopy. Interfacial adhesion was improved by EPDM addition.

Addition of EPDM to PP/LDPE blends improved mechanical properties, especially Izod impact strength in LDPE-rich blends and with higher EPDM content. They obtain that the addition of EPDM to PP/LDPE blends improved the mechanical properties, especially the Izod impact strength in LDPE-rich blends and those with higher EPDM content. Brittleness was decreased by EPDM addition. Storage modulus was decreased with LDPE addition to PP as well as with EPDM addition to PP/LDPE blends. Phase interactions of PP/LDPE with and without EPDM were observed by glass transition shifts.

Interfacial adhesion was improved by EPDM addition. The compatibilizing efficiency of EPDM on PP/LDPE blends was confirmed on improvement of elongation, Izod impact strength and brittleness, and morphological and phase structure but did not show compatibilizing efficiency on the improvement of tensile strength, except for PP/LDPE 80/20 blend.

Another example was studied by Sihama E. Salih¹, Abdulkhaliq F. Hamood¹ & Alyaa H. Abd alsalam¹: Comparison of the Characteristics of LDPE : PP and HDPE : PP Polymer Blends;(2013). The work obtained comparative studies have been made on the mechanical properties of High density polyethylene /polypropylene (HDPE: PP) and Low density polyethylene /polypropylene (LDPE: PP) binary blends.

Morphological analysis has been also performed using SEM. Blends have been prepared by melt mixing in an extruder. Mechanical tests were performed on the two groups of binary blends. Binary blends (HDPE: PP) gave higher values of tensile strength, fracture strength, young modulus, hardness, creep rate and creep modulus than LDPE: PP. The blend of ratio 20% HDPE: 80%PP shows superior mechanical properties, this blend could bear a load of 846.9 N with an extension of 3.94 mm. SEM results indicated that 20 HDPE: 80PP and 20 LDPE : 80PP are immiscible blends.

They investigated the effect of the blend ratio on the mechanical properties of HDPE: PP and LDPE: PP and the results were as following:

- 1) The mechanical properties of HDPE: PP blends gave higher values compared to LDPE: PP blends.
- 2) Mechanical properties such as (Tensile strength, Fracture stress, Young modulus, Bending modulus, creep modulus and hardness) of both HDPE: PP and LDPE: PP blend increased with increment of PP weight percentage except elongation which decreased. It has been noted that (20:80) of (HDPE: PP and LDPE: PP) appeared to withstand high loads as it is compared to other samples of other ratios.
- 3) 20HDPE: 80PP and 20 LDPE: 80PP blends are completely incompatible at which there is some phases are grossly separated.

Also Ogah, A. O. and Afiukwa J. N they studied the effects of low-density polyethylene (LLDPE) on the mechanical properties of high-density polyethylene (HDPE) film blends (2004-2012). They concluded the effect of LLDPE on the mechanical properties of HDPE film blends was investigated. Films of HDPE/LLDPE blends were produced by extrusion moulding using a Co-rotatory Twin-screw Extruder. The blends were characterized using Capillary Rheometer, Elmendorf-Type Tear Tester, MLANO/ITALIA Dart-Impact Tester and ILOE TIEH Instron Tensile Testing Machine, Model 1026. Results showed that, the Melt-Flow-Index (MFI) and tear (tensile) strength increased with increasing amounts of LLDPE, but the impact strength, yield strength and secant modulus decreased significantly. The incorporation of LLDPE into HDPE acted as a reinforcing additive. The melt flow index and the tear strength of the HDPE resin separately increased by 33.3%, hence a better processability and utility of the rigid polymer. Also, the impact strength, yield strength and modulus of rigidity decreased significantly showing an inverse relationship with the tear strength.

Chapter three: **Method and Material**

3.1 Introduction

In this research two widely used polymer materials were used:

3.1.1 polypropylene (PP):

Supplied by Khartoum Petro Chemical Company (K.P.C.).

Table 3.1.1 Specifications of Polypropylene

Grade	Nominal flow rate g/10 min	Density kg/m³	Tensile stress at Yield MPa	Flexural Modulus MPa	Izod Impact resistance J/m	Deflection temperature °C	UV stability
KP0114	8.0 – 13	910	27.5	950	20	71	No
Test methods	ASTM D1238	ASTM D1505	ASTM D638	ASTM D790	ASTM D256	ASTM D648	

3.1.2 Linear low density polyethylene (LLDPE):

Supplied by Sabic.

Table 3.1.2 Specifications of Linear low density polyethylene.

Grade	melt flow rate g/10 min	Density kg/m³	Tensile stress at Yield MPa	Puncture Resistance j/mm	Dart Impact Strength g	Vicat Softening Point °C
218N	2	918	12 10	63	85	98
Test methods	ASTM D 1238	ASTM D 1505	ASTM D 882	Sabic Method	ASTM D 1709	ASTM D 1525

3.2 Blending:

LLDPE: PP blend was mixed according to the ratios displayed in Table and melt processed in single screw Injection machine.

Table 3.2 Blend of PP&LLDPE Batches

Batch No	PP114	LLDPE
1	90%	10%
2	80%	20%
3	70%	30%
4	60%	40%
5	50%	50%

Samples prepared by (GRAND) fig(3.2) Injection moulding technique including locating previous extruded blend strips in a mold made of steel to have the suitable thickness for inspections which is previously heated at 220 °C for one hour, after prepared sample wait for 48hour at 23°C \pm 2 and 50 \pm 5% humidity to be ready for test.



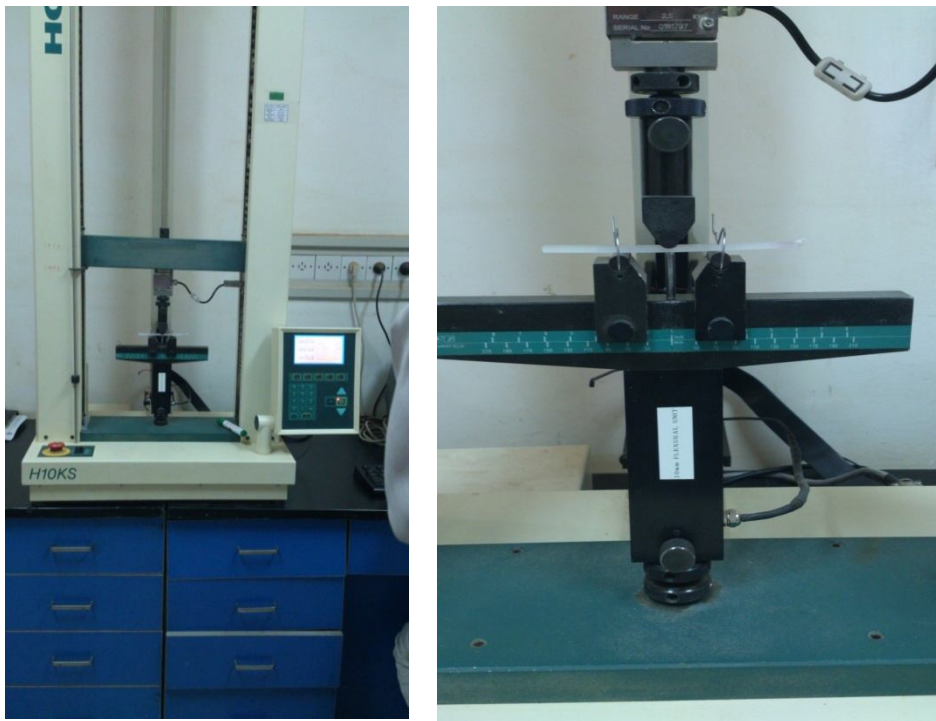
Source: Khartoum petro chemical company (K.P.C.)

Figure 3.2 Injection molding machine.

3.3 Mechanical Tests

3.3.1 Flexural Test for PP&LLDPE blend.

Samples were prepared for the Flexural test in accordance with ASTM D790 procedure, computerized universal testing Instrument (H10KS). The Flexural test ASTM D790 measures the force required to bend a plastic beam under a three point loading system. The major difference between the three point and four point flexural tests is the location of the bending moment. The four point bending method allows for uniform distribution between the two loading noses, whilst the three point bending method's stress is located under the loading nose. Since the flexural properties of many materials can vary depending on temperature, rate of strain and specimen thickness, it may be appropriate to test materials at varied parameters. The specimen taken at the Instrumented Flexural Test Device fig (3.3.1)



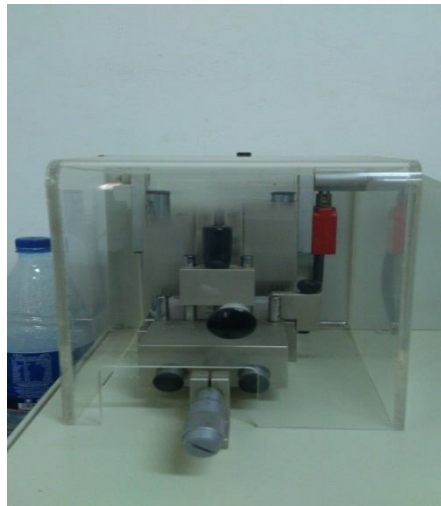
Source: Khartoum petro chemical company (K.P.C.)

Fig 3.3.1 Instrumented Flexural Test Device

3-3-2.Impact Test for PP&LLDPE blend.

Impact test is performed at room temperature according to ASTM IS D256, Izod charpy tension impact test measurement test Instrument, Time group Inc. Test, sample take two stages to be ready for testing, first stage is reduce width by Notch speed variation machine **fig (3.3.2.1)**, the second stage is measure the variation to get the final shape of sample **fig (3.3.2.2)** after that the sample **fig (3.3.2.3)** ready to test by Resil Impactor machine **fig (3.3.2.4)**.

Notched Izod Impact is a single point test that measures a materials resistance to impact from a swinging pendulum. Izod impact is defined as the kinetic energy needed to initiate fracture and continue the fracture until the specimen is broken. Izod specimens are notched to prevent deformation of the specimen upon impact. This test can be used as a quick and easy quality control check to determine if a material meets specific impact properties or to compare materials for general toughness. The specimen is clamped into the pendulum impact test fixture with the notched side facing the striking edge of the pendulum. The pendulum is released and allowed to strike through the specimen.



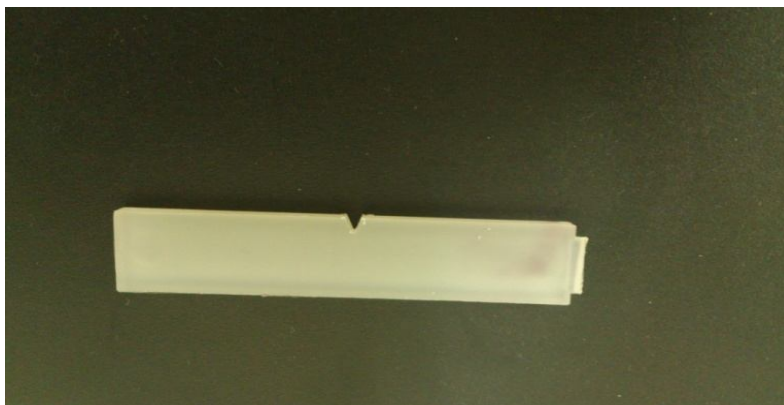
Source: Khartoum petro chemical company (K.P.C.)

Fig (3.3.2.1): Notch speed variation instrument



Source: Khartoum petro chemical company (K.P.C.)

Fig (3.3.2.2) variation instrument



Source: Khartoum petro chemical company (K.P.C.)

Fig (3.3.2.3): impact test sample



Source: Khartoum petro chemical company (K.P.C.)

Figure (3.3.2.4): Resil Impactor machine

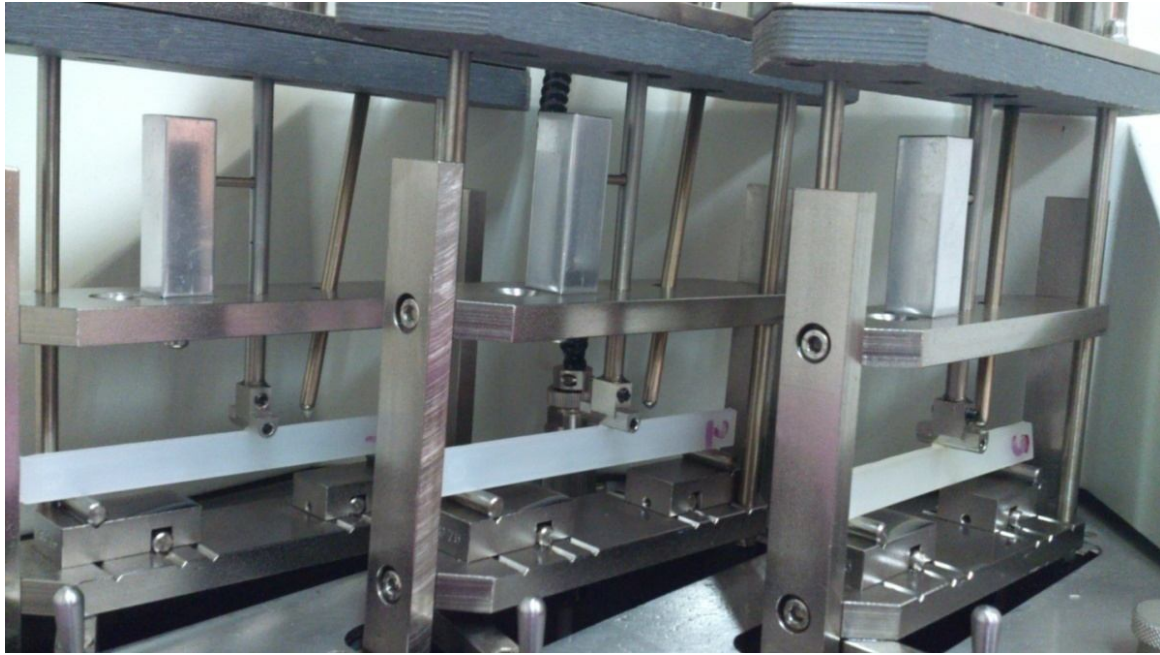
3.3.3 Heat deflection temperature(HDT) test for PP&LLDPE blend.

Heat deflection temperature test carried out at room temperature according to ASTM IS D648, by HDT.VICAT Instrument seen in **Fig(3.3.3.1)** . The sample taken as seen in **Fig(3.3.3.2)** .



Source: Khartoum petro chemical company (K.P.C.)

Fig (3.3.3.1): HDT.VICAT Instrument



Source: Khartoum petro chemical company (K.P.C.)

Fig (3.3.3.2) heat deflection test sample

3-3-4. Melt flow Index (MFI)test for PP&LLDPE blend.

Melt flow index test carried out at room temperature according to ASTM D1238, it's done by Instrument seen in **Fig(3.3.4.1)** .the sample shape seen in **Fig(3.3.4.2)**.

A small amount of the polymer sample 6g is taken in the specially designed MFI apparatus. The apparatus consist of a small die inserted in to apparatus with outside diameter 9.47mm, inner diameter 2.095mm and the length of die is 8.00mm.



Source:Sudan University department of plastic Eng.

Fig(3.3.4.1) MFI Insturement

fig(3.3.4.2) MFI sample

Chapter four: Result and Discussion

4.1 Introduction

Several unfamiliar aspects of material behavior of plastic need to be appreciated, the most important probably being that, in contrast to most metals at room temperature, the properties of plastics are time dependent. Analysis of data of dynamic mechanical properties and impact properties at various compositions of the blend revealed a direct correlation between impact properties and dynamic mechanical loss tangent. The tests done by mix different ratio of (LLDPE) to (PP) because of its high impact and toughness. The program used to analysis data is Microsoft Word.

4.2 Mechanical Tests

4.2.1 Flexural Test of PP&LLDPE blend:

The result of Flexural for the blend of LLDPE: PP was presented in the **Fig (4.2.1)** and **table (4.2.1)** shows Flexural in all the different cases. The result show pure polypropylene has low Flexural than PP & LLDPE blend at some percentage. Adding 30% LLDPE of the blend it makes slightly decrease the 10% LLDPE in flexural so it is acceptable.

Table 4.2.1 Flexural Test of PP&LLDPE blend

Batch No	Thickness (mm)	Width (mm)	Flexural Mod (MPa)
1	3.2	12.7	1328
2	3.2	12.7	1005
3	3.2	12.7	1257
4	3.2	12.7	755
5	3.2	12.7	629

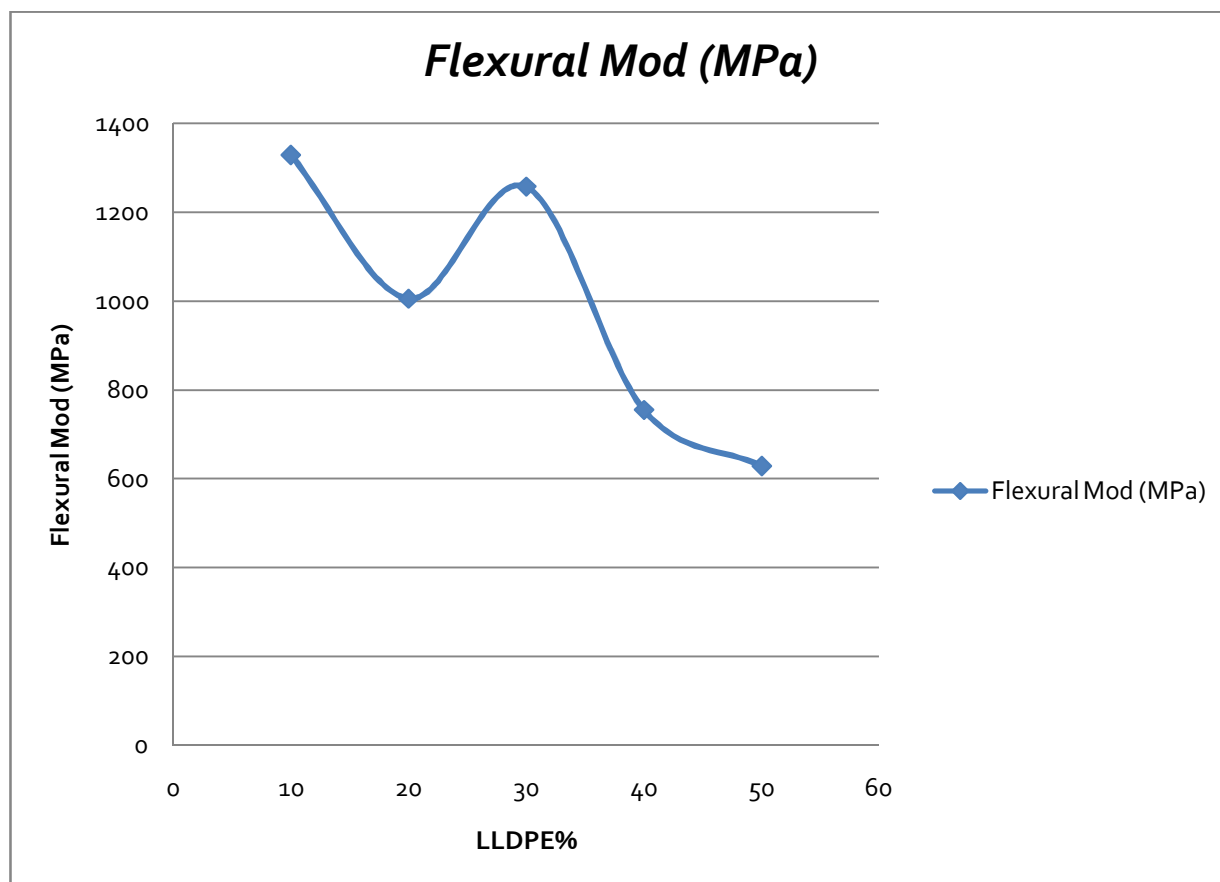


Fig 4.2.1 Flexural graph of LLDPE% of PP/LLDPE blend

4.2.2 Impact Test for PP&LLDPE blend.

The Impact toughness is 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. The result of impact for the blend of LLDPE: PP was presented in the **Fig (4.2.2)** and **table (4.2.2)** shows impact in all different cases. The study obtained the addition of LLDPE to PP led to increase the impact strength of PP in some percentage. The maximum degree of impact obtained at 30 % LLDPE of blend.

Table 4.3.2 Impact test of PP&LLDPE blend

Batch No	Thickness (mm)	Width (mm)	Notched width (mm)	Energy (J)	Impact resistance (J/m)
1	3.2	12.7	10.38	0.084	26.01
2	3.2	12.7	10.36	0.079	24.69
3	3.2	12.7	10.38	0.096	30.01
4	3.2	12.7	10.38	0.091	28.44
5	3.2	12.7	10.39	0.088	27.5

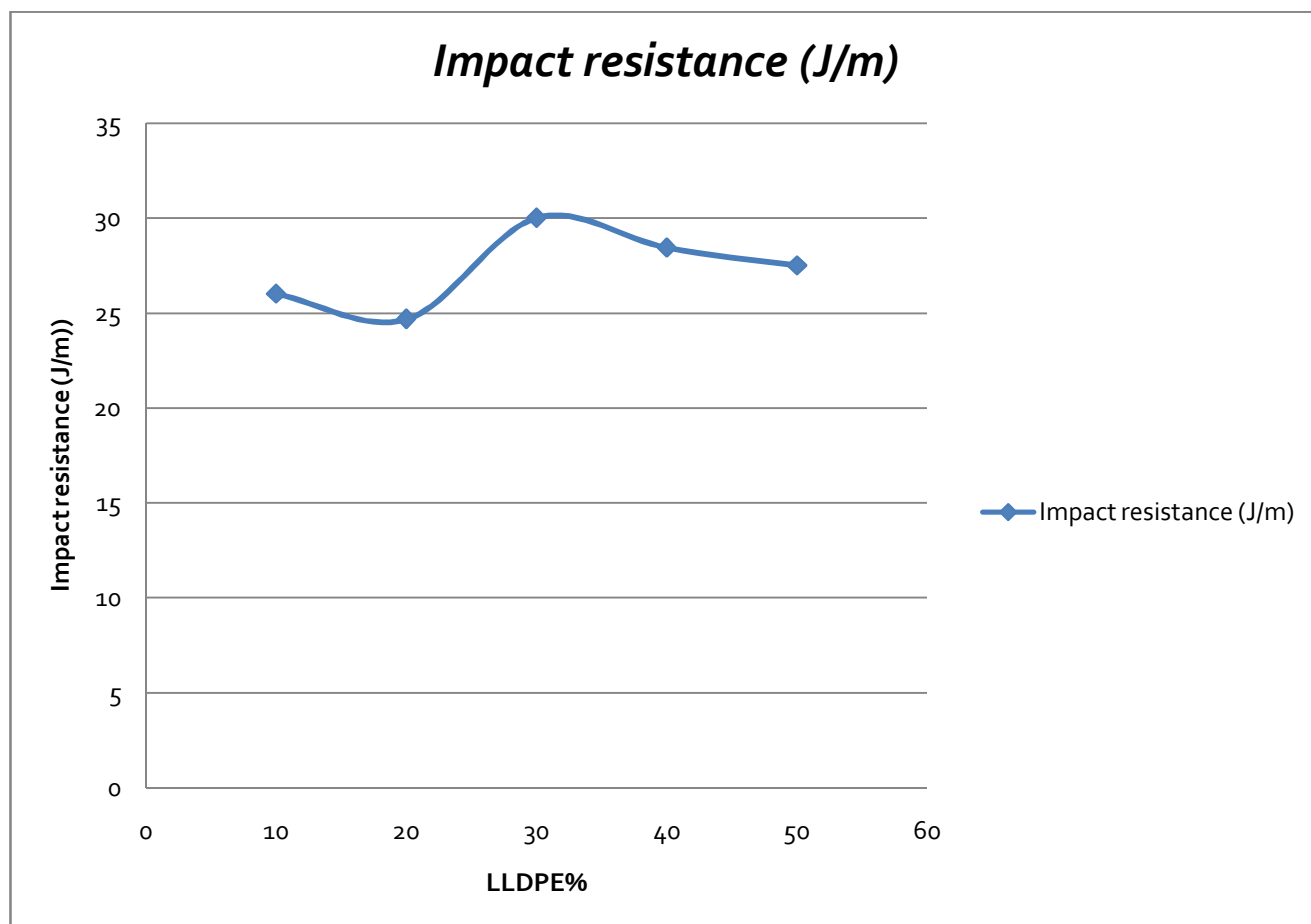


Fig (4.3.2) Impact graph of LLDPE% of PP&LLDPE blend

4.2.3 Heat deflection temperature(HDT) test for PP&LLDPE blend.

Whenever products made of polymeric materials are exposed to a constant load at constant temperature, their propensity to Heat deflection temperature which considerably affects their dimensional stability with time becomes a most important characteristic. **Table (4.2.3.1)** and **Figure (4.2.3.3)** shows deflection temperature in all the different cases. Addition of LLDPE to PP led to increase the Heat deflection temperature of the blend till 30% LLDPE of the blend above this the increasing of LLDPE led to decrease the Heat deflection temperature of the blend.

load (stress) = 0.455 MPa

Table 4.2.3 Heat deflection temperature test of PP&LLDPE blend

Batch No	HDT (°C)
1	81.2
2	86.6
3	119.4
4	80.9
5	78.9

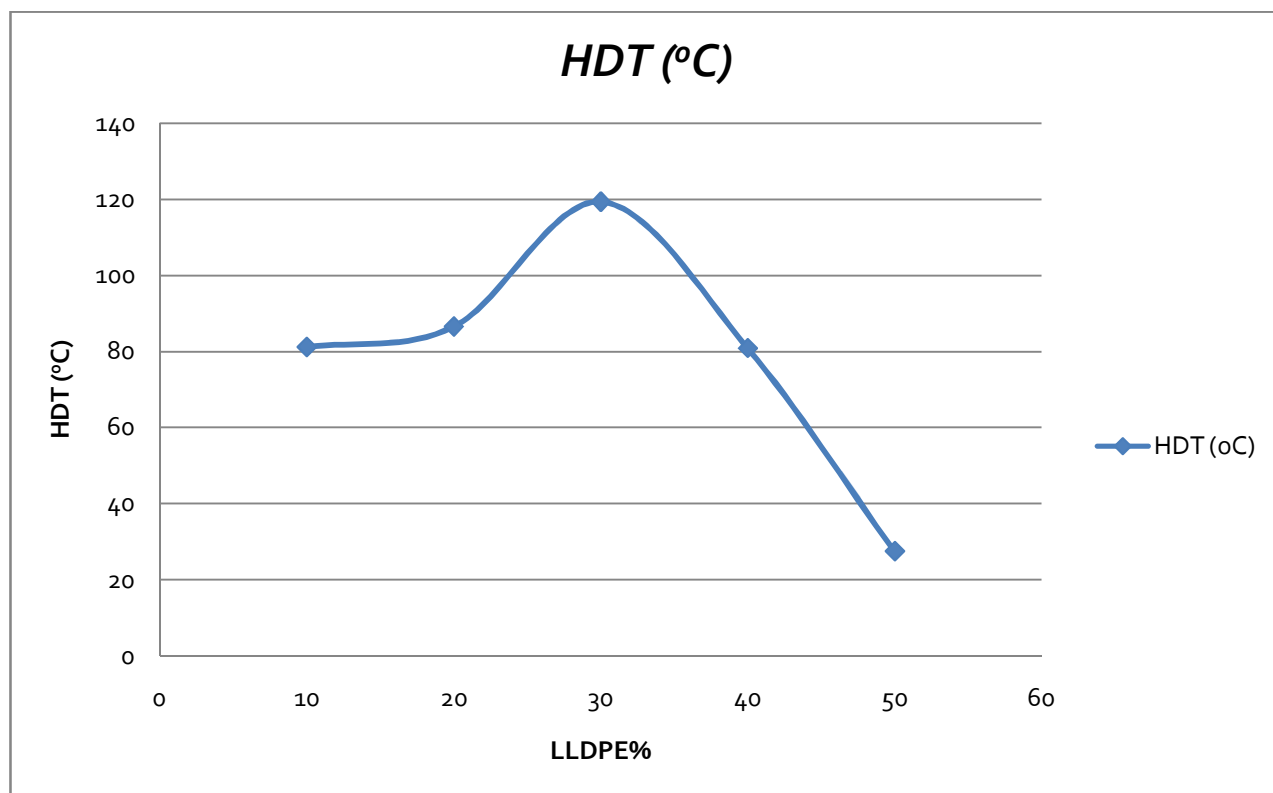


Fig (4.2.3.3) HDT graph of LLDPE% of PP&LLDPE blend

4-2-4. Melt flow Index (MFI) test for PP&LLDPE blend.

Table (4.2.4.3) and **Figure (4.2.4.3)** shows Melt flow Index in all the different cases with different ratio of LLDPE added to PP. The result shows Melt flow Index of the PP/LLDPE blend showed decrease compared to virgin polypropylene. The study obtained the addition of LLDPE led to decrease the Melt flow Index of PP.

Pure PP 114=30.87 G/10min

Table (4.2.4) Melt flow Index test of PP&LLDPE blend

Batch No.	MFI (g/10min)
1	29.53
2	26.13
3	23.53
4	18.93
5	16.50

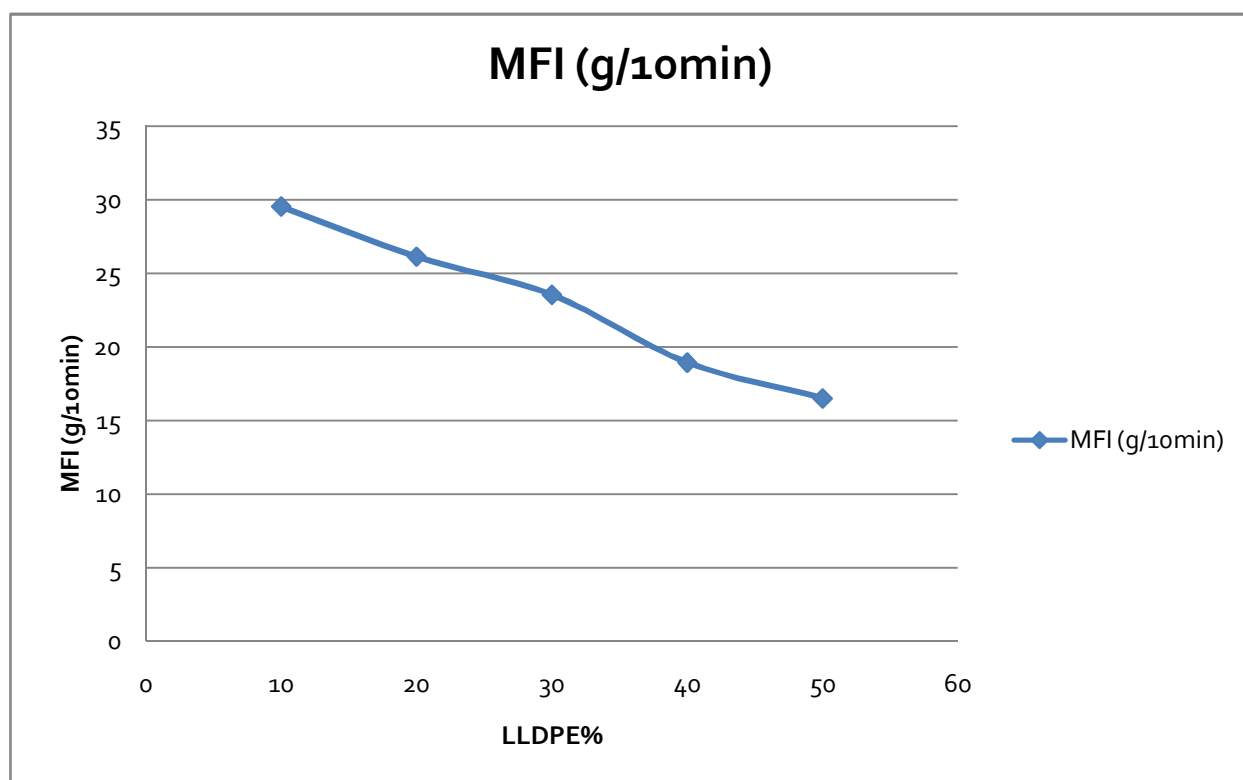


Fig (4.2.4.3) Melt flow Index graph of LLDPE% of PP&LLDPE blend

4.3 Cost Estimation:

To make new material we have to tie everything we do to gain our missions and Objectives. To find efficiencies and improve quality, they are documenting, benchmarking, analyzing and improving business and work processes.

4.3.1 Cost Estimation:

Cost Estimation is the effective application of professional and technical expertise to plan and control resources, costs, it is a systematic approach to managing cost throughout the life cycle of any enterprise, program, facility, project, product, or service[Total Cost Management Framework An Integrated Approach to Portfolio, Program, and Project Management First Edition, John K. Hollmann, PE CCE,2006]. It is very important target which need to be in mind when we make blend for two or more materials to achieve better properties than those of the individual Components used alone.

In (PP&LLDPE) blend the bag cost as flow:

1- $25\text{kg/PP} = 400 \text{ SDG} \rightarrow 1\text{kg} = 16 \text{ SDG}$.

2- $25\text{kg/LLDPE} = 500 \text{ SDG} \rightarrow 1\text{kg} = 20 \text{ SDG}$.

for example chair has weight= 1kg, Cost Estimation as flow:

Table (4.3.1) Cost Estimation of PP&LLDPE blend

PP%	LLDPE %	Blend cost
90	10	16.2 SDG
80	20	16.8 SDG
70	30	17.2 SDG
60	40	17.6 SDG
50	50	18 SDG

From table(4.3.1) the cost of the blend 30% LLDPE and 70% PP is obtained cost about 17.2 SDG manufacture 1KG chair.

Chapter Five:

Conclusion and Bibliography

Conclusion:

- Impact Test for PP&LLDPE blend showed maximum impact at 30% of LLDPE.
- The Flexural Test of PP&LLDPE blend improved by the addition LLDPE until 30% more than that it showed decreasing.
- Heat deflection temperature test of PP&LLDPE blend result is maximum Heat deflection temperature at 30% of LLDPE for the blend.
- Melt flow index test of PP&LLDPE blend showed that it decrees with increase of LLDPE amount.
- Cost estimation of the blend 30% LLDPE and 70% PP is obtained cost for manufacture chair.

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