

Studying The Properties of PP/LDPE polymer blend

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الخلاصة:

يدرس هذا البحث مجموعة من الخواص الميكانيكية والحرارية والفيزيائية لخليط بوليمري من البولي بروبيلين والبولي ايثيلين الواطئ الكثافتوم دراسة نسب الخلط التالية (25/75 ، 50/50 ، 75/25) بالإضافة الى البولي بروبيلين والبولي ايثيلين واطئ الكثافة النقيين، اظهرت النتائج ان اضافة البولي ايثيلين الواطئ الكثافة الى البولي بروبيلين ساهمت في تقليل مقاومة الشد ومقاومة الانحناء ومعامل الانحناء والصلادة وتحسن الكثافة ، عند النسبة (75/25) من الخليط تم الحصول على أعلى مقاومة شد بينما أفضل مقاومة انحناء تعطيتها نسبة الخلط (50/50).

الكلمات الدالة:البولي بروبيلين ، خليط،البولي ايثيلين الواطئ الكثافة ، المسعر الماسح التفاضلي ، خواص الشد و الانحناء.

ABSTRACT:-

This research studies some of the mechanical, thermal and physical properties for a polymer blend of polypropylene(PP)&low density polyethylene (LDPE). The blend compositions under studying were(pure PP, 25LDPE/75PP,50LDPE/50PP,75LDPE/25LDPE,pure PP). From the results it can be observed that the addition of LDPE to PP has been declined the tensile strength, flexural strength, flexural modulus and hardness while the density improved . the superior tensile strength was obtained at (25LDPE/75PP) composition while preferable flexural strength was ascribed to (50LDPE/50PP) blend composition.

Keywords: polypropylene, blend, low density polyethylene, differential scanning calorimeter, tensile and flexural properties.

1.Introduction:

Polyolefin are the most important plastics. Polyethylene and polypropylene have the most products and lies in the first position of plastics ,interest in PP andPE 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 .[Dikobe,2010]

LDPE is not reactive at room temperatures, except by strong oxidizing agents, and some solvents cause swelling. It can withstand temperatures of 80 °C continuously and 95 °C for a short time. It is quite flexible, and tough but breakable.LDPE has more branching (on about 2% of the carbon atoms) than HDPE, so its intermolecular forces (instantaneous-dipole induced-dipole attraction) are weaker, its tensile strength is lower, and its resilience is higher. Also, since its molecules are less tightly packed and less crystalline because of the side branches, its density is lower(density range of 0.910-0.940g/cm³).[Riyaz,2013]

PP is a very poor conductor of electricity and makes a very good insulating material that ranks better than most other plastics. At the same time this has the side effect that the material builds up static electrical charges on the surface.Polypropylene is non-polar because it is composed of carbon and hydrogen atoms and non-polar atoms such as oxygen, so non-polar molecules are generally soluble in non-polar solvents, PP is resistant to attack by polar chemicals such as soaps, wetting agents, and alcohols. Due to its non- polar nature PP is water repellent and is not affected in dimensions or properties by changes in RH.[McCrum,1997])

Apart from these good properties that PP 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 PP drawbacks can be considerably improved by blending PP with other polymers. The blending of polymers provides an efficient way of developing new materials with tailored properties and is often a faster and more cost effective means of achieving a desired set of properties than synthesizing a brand new polymer [Dikobe2010, RAnjana 2012]

Immiscible polymer blends are much more interesting for commercial development since immiscibility allows to preserve the good features of each of the base polymer components of the blend. Some properties can be achieved only through immiscible polymer blends Fig.(1). For example the impact strength of a polymer cannot be improved significantly by adding an elastomer miscible with it. Polyolefin blends are frequently used to get the balanced mechanical and processing properties. The properties of individual polyolefin can be changed in a significant way by mixing with other components. For this reason polyolefin blends have attained widespread commercial applications. [Utracki2002, McCrum 1997]

Blending of PP and different PEs largely depend on the miscibility or immiscibility of the two components. PP and LDPE or HDPE are generally considered immiscible in the whole composition range and show a remarkable phase separation during cooling/crystallization. Pure Polyethylene PE and polypropylene PP and their blends PE/PP have attracted considerable industrial attention. [Utracki2002, Yousef2011]

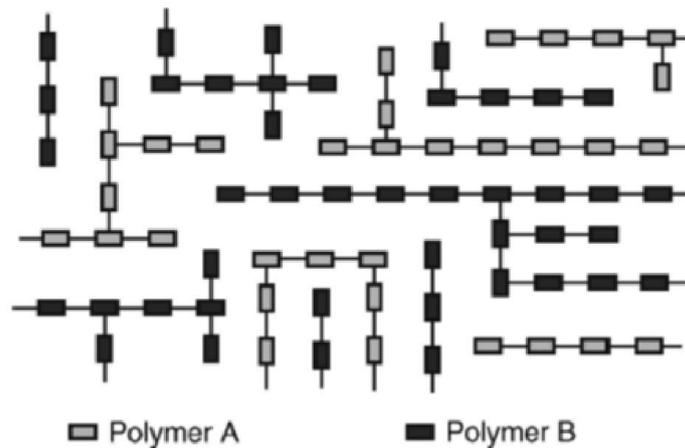


Fig.(1): Schematic molecular structure of polymer blends. [Utracki2002]

2. Literature Review:

In 1995 Xiaodong Wang and others studied the blends of (PP) and ultrahigh molecular weight polyethylene (UHMWPE) were prepared by the four –and twin screw extruders and the ethylene-propylene-diene monomer (EPDM). the miscibility enhancement effect of EPDM on PP/UHMWPE blends is very remarkable. Mechanical and thermal properties demonstrate the melt blending by the four-screw is a better processing method for PP/UHMWPE blends than twin screw extruder. [Wang 1995]

In 1997 I.Z Liar & J.N.Nessb studied a blown film extrusion grade PP was melt blended with an injection grade HDPE and a blown film extrusion grade (LDPE) using an extruder and the capillary flow properties. The end pressure losses were increased for PP/HDPE blends and decreased for PP/LDPE blends. The flow properties of PP melt improved when it was melt –blended with HDPE or LDPE. [Liar 1997]

In 2005 R. Strapasson and others (2005) studied PP/LDPE blends via injection molding carried out under various injection temperatures. The behavior of the blend was also very dependent on processing temperature. An addition of 25% of LDPE to PP may result in similar degradation of its mechanical properties to that caused by a 10°C processing temperature increase. [Strapasson 2005]

In 2013 R. K. Krastev, S. Djoumalisky, I. Borovanska studied the long-term strength of five composites made of plastic waste. They contain (LDPE, HDPE, PP and PS). Long-term strength is determined experimentally by tensile creep to fracture. The composite containing 50 wt.% PS has the greatest strength (of the tested specimens) and has brittle fracture. Its calculated estimate of long-term strength is not consistent with the experimental one. [Krastev 2013]

In 2014 Nabila Guerfi, Naima Belhaneche studied the valorization of two regenerated (LDPE) coming from dirty wastes by blending with (PP) in presence of a compatibilizer. The results showed that this kind of blending has contributed considerably in performing properties of regenerated LDPE. [Guerfi 2014]

In this work, the evaluation of mechanical and thermal properties of PP/LDPE blend was carried out to investigate the composition range for better mechanical & thermal performance.

3. experimental part:

3.1 Equipment:-

1. Twin Screw extrusion machine of polymer: Model SLJ-30A, screw diam. 30mm, heating power 3kw, main motor 4kw, speed is (0-320)rpm.
2. Saw Electrical Device (Einhell RT-SB305U).
3. Grinding Electricity Device (Bench Grinder BG611)
4. High precision density tester (Gp-205)
5. Microcomputer Controlled Electronic Universal Testing Machine: Model WDW-5E, tensile and flexural fixtures; D638, D790 for tensile and flexural specimens.
6. Hardness Device (Shore D TH210).
7. DSC -60 differential scanning calorimeter Shimadzu.

3.2 Sample Preparation:-

Sample preparation process including three stages:

First: PP granular (100g), 75PP/25LDPE, 50PP/50LDPE, 75PP/25LDPE, 100LDPE have been extruded through fine orifices of the twin screw extruder machine at 175°C and cooled by air.

Second: after extrusion process, each polymer sheet various proportions has been cut into samples of (tensile, flexural, density, hardness, and thermal test) by using saw electrical device.

Third: before the mechanical tests, grinding has been carried out for each sample by applying grinding machine. Number of samples are 25: 5 for each test (tensile, flexural, hardness, density, and DSC)

4. Results and Discussion:

Figs. (2), (3), (4) & (5) represent the ultimate tensile strength, the load-deformation curves, the flexural stress-flexural strain and the flexural strength for the following blend compositions (pure PP, 25LDPE/75PP, 50LDPE/50PP, 75LDPE/25PP, pure LDPE). It can be observed that the ultimate tensile strength and flexural strength were declined with the addition of low density polyethylene, superior tensile strength was obtained at the composition (25LDPE/75PP) and preferable flexural strength were at the composition (25LDPE/75PP). This behavior ascribed to two reasons: one reason is the phase separation of PE where its particles serve as the

nucleating agent for PP and the spherulite size of PP is decreased, which is adverse to the crystallinity of PP (PP has low crystallinity). The second reason is that LDPE has a lower tensile strength and flexural strength in comparison to PP, thus the higher content of LDPE content, the lower crystallinity of PP and consequently tensile and flexural strength. [Lin Jia 2015]

Fig.(6) shows shore-D hardness of (PP+LDPE) blend versus LDPE% where the maximum hardness of pure PP was 67.6 and declined with increasing the proportion of LDPE reaching to 59 for LDPE alone. This was belonged to the reason that the addition of LDPE to PP will decrease hardness and increase toughness of PP] and to the molecular structure of LDPE which has more side branches that can be formed and caused loose packing of the molecular chains, so branching of linear polymers weakens secondary bond between the chains and lower the hardness of the bulk polymeric material, as compared to the PP which has side groups structure (methyl groups) that provides considerable steric hindrance and make polymeric material rigid and relatively strength. [Utracki L 2002, Salih 2015]

Fig.(7) represents the increasing of density with the addition of LDPE where the calculated density of PP is 0.9 g/cm³ while density was increased into 0.937g/cm³ for LDPE alone because density is a gauge of the crystallinity index where the larger density value, the higher the crystallinity index which mainly affecting the product's properties [Makoto 2009].

Figs.(8,9,10,11,12) represents DSC curves due to the relation between amount of power in (mW) and temperature in (°C) with heating rate (10°C/min) from (20-200°C).

Hint: from DSC curves, the reaction is endothermic while the heat of fusion in minus sign was followed the type of DSC apparatus.

LDPE %	Melting Temperature °C		Heat of fusion mJ		Degradation Temperature °C
0	-	156.6	-	150	214.5
25	124.8	154.8	176	211	213
50	124.5	154	247	96.7	209.8
75	124	154	152	32	207
100	125.7	-	402	-	186

Table(1): values of melting temperatures, heat of fusion, and degradation temperatures from DSC for PP/LDPE blend.

According to table (1), it can be observed that with increasing the proportion of LDPE the degradation temperature will decrease according to the lower melting point of LDPE as compared with PP, during this degradation cross linking will occur because of the formation of free radicals and active sides.

The presence of two melting peaks indicates that the main chemical structure of PP and LDPE were not related, because both LDPE and PP are polyolefin polymers and not compatible. In addition a significant presence of phase separation between PP and LDPE proves that the blend are formed via a physical blend (immiscible blend) [Lin Jia 2015].

5. Conclusions

1. The tensile strength, flexural strength, flexural modulus and hardness of the blend has been decreased monotonically with increasing LDPE as a result to the nature of LDPE which is more flexible than PP.
2. the density data of blend was improved according to the addition of LDPE.
3. Degradation temperature of blend has been declined with the addition of LDPE.

4. PP/LDPE blend is immiscible & physical blend.

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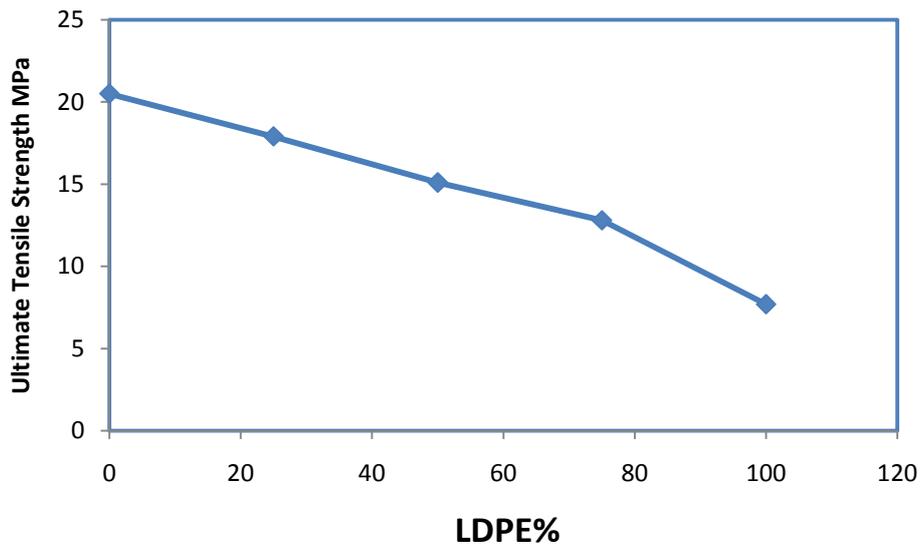


Fig.(2):Ultimate tensile strength of PP/ LDPE blend.

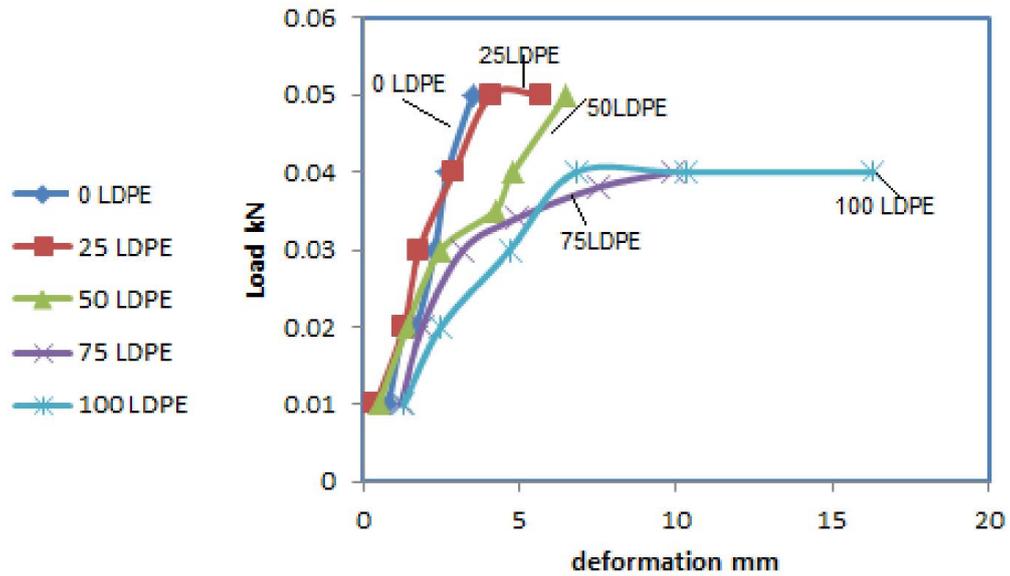


Fig.(3):Load -deformation for three points flexural test of PP/LDPE blend.

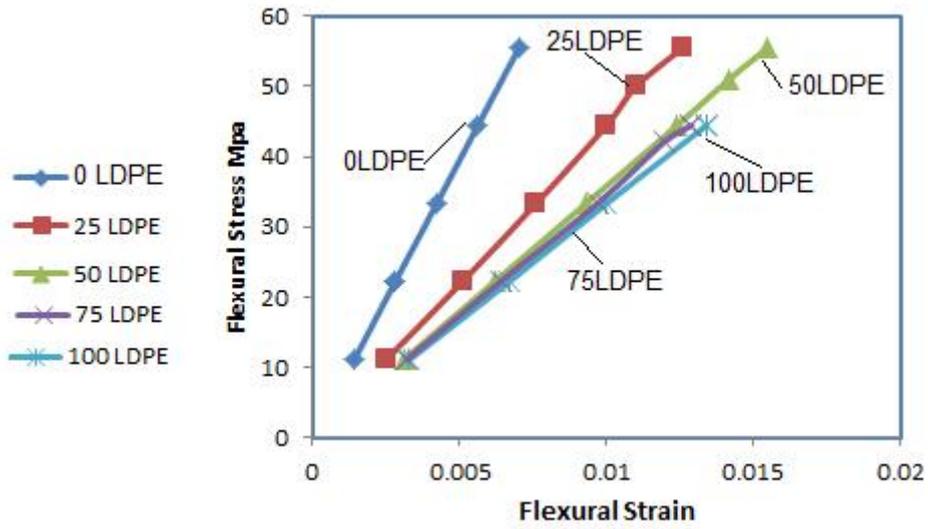


Fig.(4):Flexural stress and flexural strain for PP/LDPE.

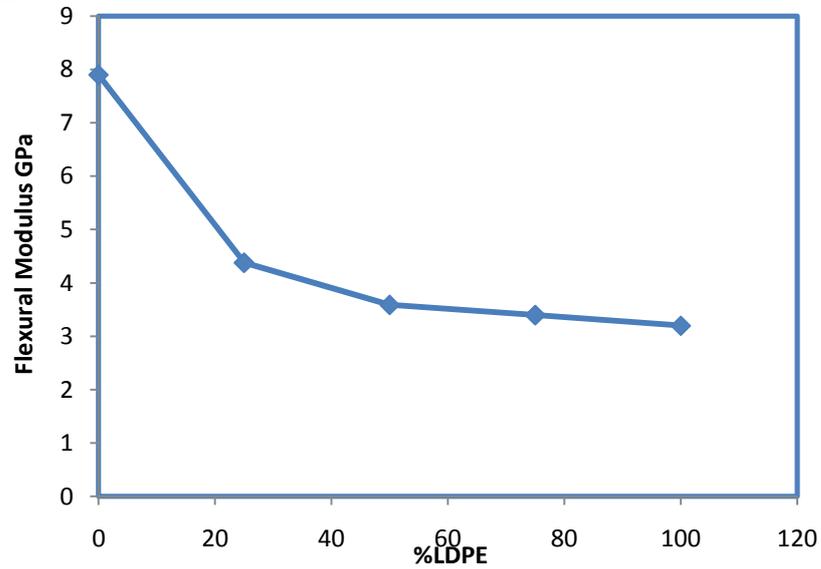


Fig.(5):Flexural modulus of PP/LDPE.

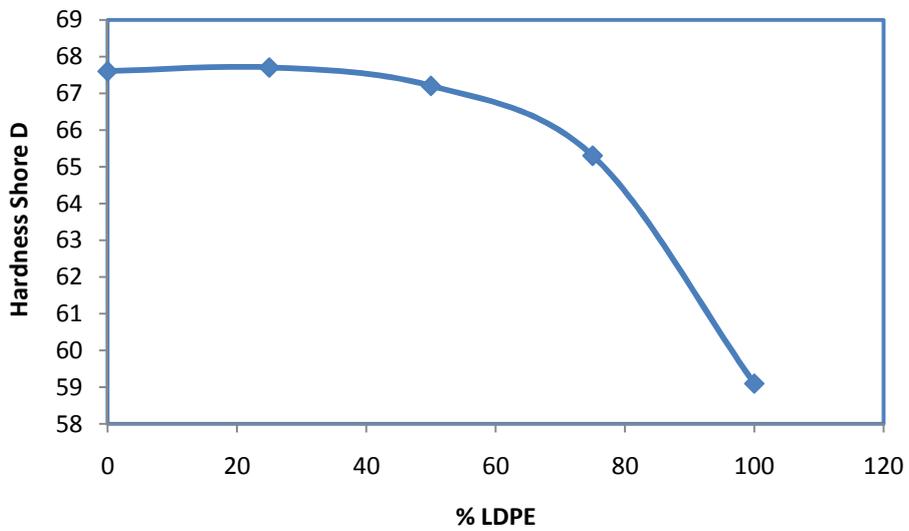


Fig.(6): Hardness Shore D of PP/LDPE blend.

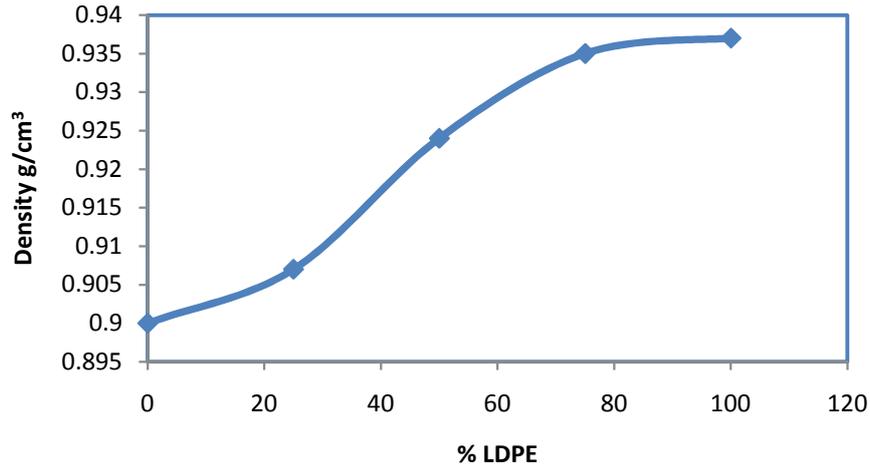


Fig.(7):Density of PP/LDPE blend

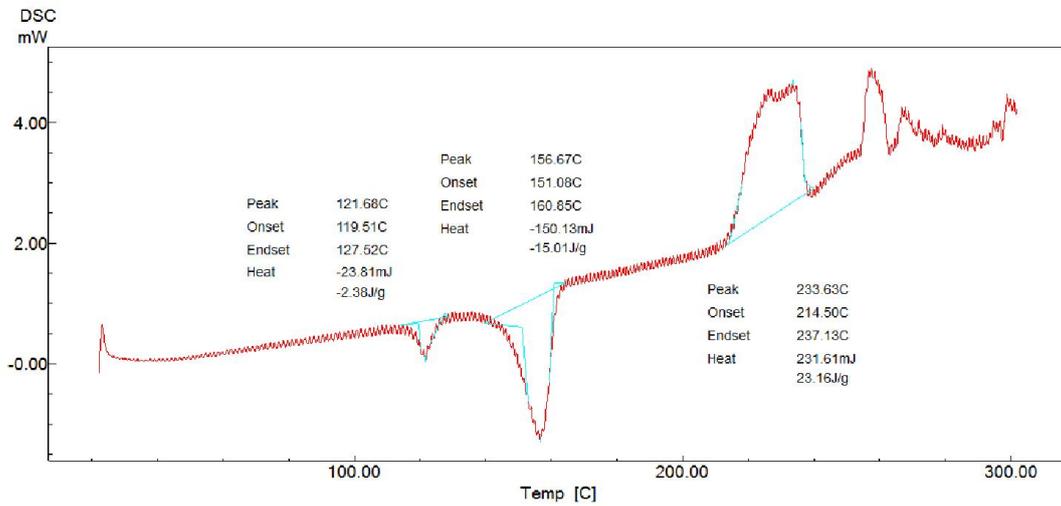


Fig.(8):-Differential Scanning Calorimeter Curve PP Pure.

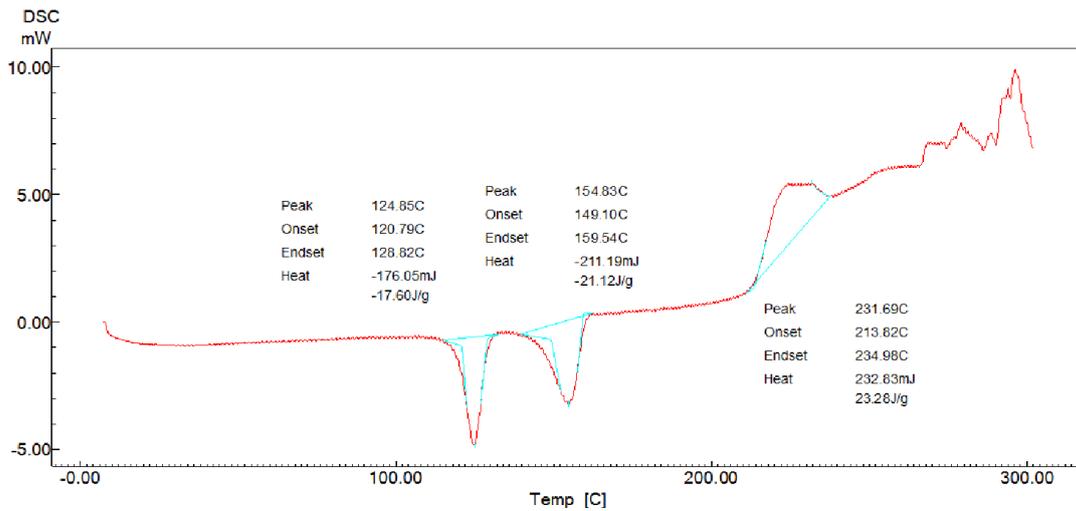


Fig.(9):-Differential Scanning Calorimeter curve for 25 LDPE / 75 PP.

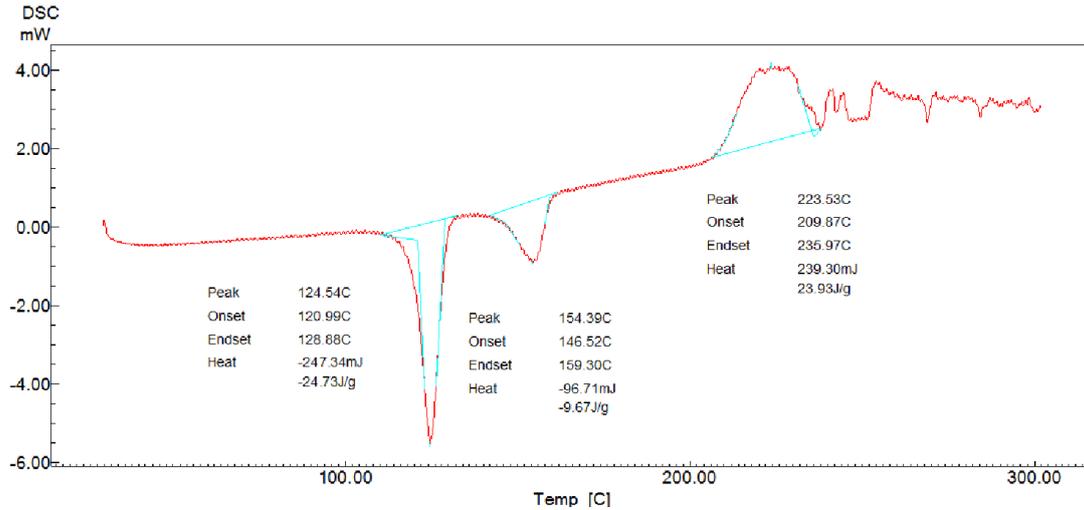


Fig.(10):-Differential scanning calorimeter curve for 50 LDPE / 50 PP.

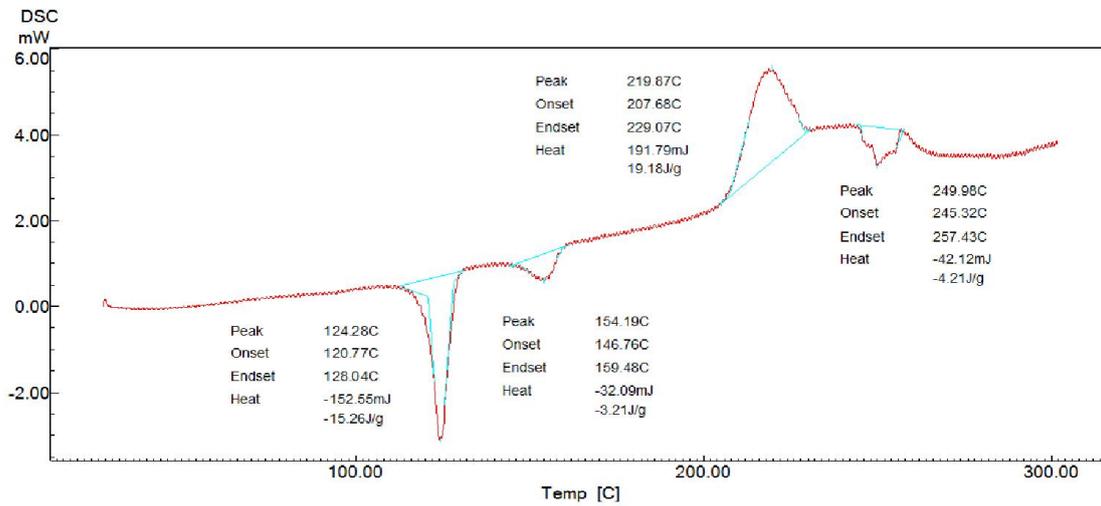


Fig.(11):-Differential scanning calorimeter curve for 75 LDPE / 25 PP.

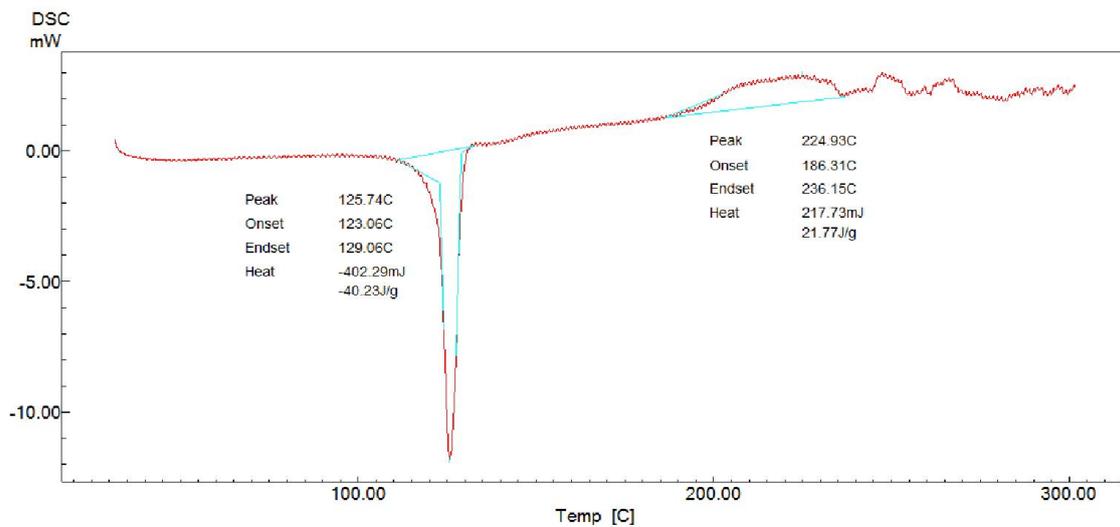


Fig.(12):-Differential scanning calorimeter curve for pure LDPE.