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*Preparation and characterization of LDPE /PVC/ Mgo
blend composite for industrial applications*

**A graduated project submitted to Department of polymer and petrochemical
industries**

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(بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِیْمِ)

(یَرْفَعِ اللّٰهُ الَّذِیْنَ اٰمَنُوْا مِنْكُمْ وَالَّذِیْنَ اٰوْتُوْا الْعِلْمَ دَرَجٰتٍ
وَاللّٰهُ بِمَا تَعْمَلُوْنَ خَبِیْرٌ)

صدق الله العظيم

الإهداء

إلى سبب وجودي الذي ضحى بسعادته لأنعم بالراحة وإيصالي لطريق *
النجاح والدي العزيز

إلى منبع الحب والحنان الى التي امتزج فرحها بفرحي وحننها بحزني *
والدتي الحبيبة

إلى الذين حملوا أقدم رسالات الحياة من زرعوا فينا الأمل وحب العلم *
والمعرفة أساتذتي الأفاضل

أهديكم ثمرة جهدي وعطائي

شكر وتقدير

يطيب لي وأنا انهي دراستي أن أتوجه بخالص شكري وأمتناني وعميق اعترازي الى أستاذتي م. م (بان جواد كاظم) التي كانت لملاحظاتها العلمية الرصينة وتوصياته السديدة بالغ الاثر في انجاز هذا البحث بهذا المستوى العملي فلها مني الشكر والعرفان.

كما يشرفني إنني أتقدم بخالص الشكر للاستاذ (اثير حسين مهدي) ولأستاذتي في كلية هندسة المواد /قسم البوليمرات والصناعات البتروكيماوية ، لما قدموه من توجيهات سديدة وتشجيع دائم طيلة سنوات الدراسة الأربعة.

وفي الختام أتقدم بخالص الشكر والامتنان لأستاذتي الأفاضل لجنة المناقشة المحترمين لمناقشة بحثي وما سوف يبدونه من ملاحظات وأراء علمية سديدة تشكل أغناء وترصيناً علمياً لهذا البحث، واسأل الله عز وجل أن يوفقنا جميعاً لما فيه الخير والصلاح...ومنه التوفيق

Supervisor

*I certify that the dissertation entitled “**Preparation and characterization of LDPE /PVC/ Mgo blend composite for industrial applications**” was prepared under my supervision at the Department of Polymer and Petrochemical Industries / College of materials engineering /University of Babylon.*

Signature:

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Date: / / 2023

Abstract

Polymer blend :- A polymer blend is mixture of two or more polymers That have been mixed together to create a new materiel.Many applications need any specific properties for the purpose of meeting the need for them. Among these properties are mechanical and thermal properties, as polymers usually have low mechanical and thermal properties compared to the rest of the materials, so we usually resort to using other materials that are added to polymers, including nanomaterials.

In this study, six samples of LDPE and PVC were prepared in different proportions.Through the tests that we conducted, wherever (Tensile, Hardness, DSC) tests were conducted.

By the **hardness test** that we made, When adding PVC to LDPE leads to a decrease in the hardness as a result of increasing the flexibility of the PVC and as a result of the incompatibility between the two polymers, as well as when adding Mgoit was found that the hardness increases because Mgoit has a higher hardness and thus improving the hardness of the polymeric mixture.

From the **tensile test**, we notice When PVC is added to LDPE, we notice a decrease in tensile strength When a ratio of 10-50. When adding Mgo at (1)%, we notice that the mechanical properties have improvedWhere the amount of tensile strength increased .

The amount of tensile strength was increased when adding 1% of Mgo, and the modulus of elasticity (E) was also increased, so the elongation decreased.

The reason for this is that the increase occurred as a result of adding Mgo nanoparticles, which in turn worked to blend LDPE and PVC. The hardness of the material also increased when adding Mgo nanoparticles, and this is an indication of the decrease in elongation .

From the **(DSC) test**, we note When addingMgo to a mixture LDPE/PVC, it was found that the melting point improved slightly. The reason for this is the high melting pointMgo, which improves the material's resistance to heat.

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Chapter One
Introduction
and
Literature Review

1.1 Introduction For Composite Polymer

Polymer Nanocomposites

Nanocomposites have been studied for Nearly 50 years. They were first referenced As early as 1950[1]. Polyamide nanocomposites were reported in 1976 [2]. It was the Efforts of Toyota research group that laid The foundation stone for the interest in this Area [3,4]. Nanocomposites are a combination of two or more phases containing different compositions or structures where at Least one of the phases is in the range of 10 To100 nm. Fillers with a particle size in the Nanometer range have a small number of Atoms per particle and for this reason may Have different properties than the bulk material and strong interactions with the matrix. The separation of fi ller particles is of The order of molecular dimensions, which May modify the properties of polymers. In Polymer nanocomposites research, the primary goal is to enhance the strength and Toughness of polymeric components using Molecular or nanoscale fi llers. Composites That exhibit a change in composition and Structure over a nanometer scale have shown Remarkable property enhancements relative To conventional composites:

- Increased modulus
- Increased gas barrier
- Increased heat distortion temperature
- Resistance to small molecule permeation
- Improved ablative resistance
- Increase in atomic oxygen resistance
- Retention of impact strength.

Interestingly, these performance improvement are achieved without increasing the Density of the base polymer, without degrading its optical qualities and without making It any less recyclable. It is a remarkable fact that in addition to The profound changes in physical properties, which materials display when they are Nanometer in scale, the chemical behavior is profoundly altered as well. When an Inorganic solid is composed of only a few Thousands of atoms, it has a great deal of Surface area. By binding an appropriate organic molecule to this inorganic surface, It is possible to make nanocrystals behave Chemically just like an organic macromolecule. In nature, polymer inorganic nanocomposites materials are frequently encountered (for

Example, bone, tendon, dentin and bamboo) And represent some of the finest examples of The optimized interfacial interaction. However, it is still inherently difficult to reproducibly generate polymer inorganic composite Architectures with the level of nanometer Scale sophistication responsible for the remarkable properties of biological composites.

Consequently, one of the frontiers in nanotechnology is the advancement of viable methods for the efficient design and synthesis of Polymer inorganic nanocomposites with architectural control and improved properties as Aresult of this sophistication. A wide variety Of method has been employed to synthesise Polymer inorganic nanocomposite. Depending on whether the inorganic component is Grown in the presence of the polymer (monomer) matrix or pre-fabricated, these methods Can be basically divided into two categories ‘in-situ’ and ‘ex-situ’. Among all these synthetic strategies, the assembly of inorganic Nanoparticles into a polymer matrix appears To be one of the most promising approaches. Nanoparticles are readily obtained and have Potentially useful optical, optoelectronic and Material properties deriving from their small Nanoscopic size. These properties might lead To wide applications including chemical sensors, spectroscopic enhancers, quantum dot And nanostructure fabrication and micro imaging methods. Again, the interfacial interaction between inorganic nanoparticles and Polymer matrix exerts important influence on The properties of the resulting nanocomposite. As a result, tailoring and manipulating Interfacial interaction becomes a particular Preparative challenge.

1.2 Properties of Nanocomposites

1.2.1 Mechanical properties

Schueneman et al. [5] reported that there Exists an increase in hardness and scratch resistance with the addition of nanoparticles To polymer matrix. Kojima et al. [6] reported that by intercalating as little as 2 vol % Silicates into nylon-6 on a Nano-scale, the Tensile strength and modulus of the hybrid Were improved to more than twice that of The virgin polymer. Again Kojima et al. [7] Showed that only 10 phr of organic clay Was necessary to achieve tensile strength Comparable to a compound loaded with 40 phr of carbon black. It was shown that Tensile strength and elongation at break Were improved depending on filler loading And

compatibilisation. Exfoliated polymer-Silicate systems have been found to exhibit Superior mechanical properties to the conventionally filled systems. Strawhecker et al. [8] studied the mechanical properties of PVA-Na⁺ montmorillonite nanocomposites. The mechanical tensile properties of these Nanocomposites were studied at low silicate Loadings, and Young's modulus was found to Increase by 300 % for 5-wt % silicate, with Only a 20 % decrease in toughness, and no Sacrifice of the stress at break compared to The case of neat PVA. In addition, for these Low loadings, thermal stability from TGA Measurements was shown to be slightly enhanced, and high optical purity was retained.

Granteretal[9] studied the mechanical Properties of rubber nanocomposites using BR and SBR vulcanisates reinforced by Organophilic layered silicates. It was shown That in the absence of coupling agent, the Compounds containing layered silicates show Increased tensile strength and strain at break With respect to unfilled vulcanisates. When Compared with silica compounds, both SBR And BR vulcanisates showed good enhancement in mechanical properties. But when The matrix is chemically bonded to silica By TSEPT, tensile strength remains constant, But strain at break decreases. A similar effect is observed for anisotropic layered silicates also. This is owing to the fact that the Reactive coupling of the elastomer matrix is Also effective on the surface of silicate layers Containing quaternary ammonium salts on The surface. From the hysteresis studies, improved reinforcement by 20–50 % relative to Silica vulcanisatesis observed for BR and SBR Organ clay compounds. Chemical bonding of The rubber matrix led to further increase in Reinforcing effect by 50 %–90 % relative to The corresponding silica systems. All the mechanical properties, including Young's modulus, stress at break, strain At break of all nanocomposites and virgin Polymers, were studied by Zheng and Wilkie For polystyrene nanocomposites[10]. At low Amounts of clay, the mechanical properties Are improved. As the amount of clay increases, there is a decrease in all of the mechanical properties. It is possible that above some Level, there is some plasticisation, which results in a reduction of the melting point or Softening point.

1.3 Aims of this work

Current work aims to the following steps :

1-to identify the mechanical and thermal properties of the polymer blend.

2- Study the effect of adding nanoparticles to the polymer blend and its effect on the mechanical and thermal properties .

1.4 Literatures Review

In 2017, SitiNikmatin, et al, studied Physical, thermal, and mechanical properties of polypropylene composites filled with rattan nanoparticles. Results showed their composites behaviors are directly compromised. Existing evidence has exhibited that nanoparticle fillers can be employed as an alternative size to overcome this problem. We thus examined in this study the effects of rattan filler of nanoparticle size on the physical, thermal, and mechanical properties of the composite. Neat polypropylene (PP), PP with 5% rattan nanoparticle (PP/R5), and PP with 5% glass fiber (PP/FG5) were considered. For performance assessment, particle size analysis, morphology, X-ray diffraction, thermal inspection, and mechanical tests were carried out. The highest degree of crystallinity was discovered in PP/R5. Tensile properties of both PP/FG5 and PP/R5 were comparable although the former demonstrated higher moduli of elasticity and rupture. Well-distributed constituents were displayed in PP/R5 by means of morphological study, which offered insight into its highest average hardness, maximum strain, and therefore its advantageous ductile behavior compared to the other considered materials [11].

In 2018 ,HarekrushnaSutar, et al, studied Mechanical, Thermal and Crystallization Properties of Polypropylene (PP) Reinforced Composites with High Density Polyethylene(HDPE) as Matrix Results showed in Our work aims to evaluate a complete outlook of virgin high density polyethylene (HDPE) and polypropylene (PP) polybLends. Virgin PP of 20, 30 and 50 weight% is compounded with virgin HDPE. The properties like tensile strength, flexural strength, Izod impact strength are examined. Scanning electron microscopy (SEM) and polarised light microscopy (PLM) are used to observe the surface and crystal morphology. X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR) tests verify the non compatibility of both polymers. Differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA) techniques are used to study the thermal behavior of composites. The results manifest co-occurring spherulites for polyblends; indicating the composite to be a physical blend of continuous and dispersed phases, but on the other hand PP improves the tensile and flexural properties of HDPE [12].

In 2020, Isabella L. M. Costa¹, et al, studied Thermal and Mechanical Properties of HDPE Reinforced with Al₂O₃

Nanoparticles Processed by Thermokinetic Mixer. The results showed Polymer nanocomposites are a promising area of research due to quite superior to the conventional composites. However, obtaining a homogeneous distribution of the nanoparticles in the matrix has been a great challenge. Standard processing techniques of nanocomposites are non-practical, requiring longer periods and can affect both mechanical and thermal properties of the final product. The thermokinetic mixer is an interesting alternative due to its high-speed rotation leading to a better dispersion of the nanoparticle without compromising the polymer properties. This paper reports for the first time a nanocomposite of high-density polyethylene (HDPE)/Al₂O₃ processed by the thermokinetic mixer. The addition of Al₂O₃ nanoparticle (0 to 4% wt) to the HDPE led to an increase in both the melting and crystallization temperature. It was also observed an improvement of the mechanical properties due to the increase in the crystallinity degree, which is a consequence of the multiple nucleation sites of Al₂O₃ nanoparticles. An optimal composition was obtained at 4% wt of Al₂O₃. Thus, the nanocomposites processed by the thermokinetic mixer demonstrated a significant enhancement of the mechanical and thermal properties [13].

Chapter Two
Theoretical Part

2.1 Introduction

Polymer blend (PB): Mixture of at least two macromolecular Substances, polymers or copolymers, in which the ingredient content is Above 2 wt%. A polymer blend is a mixture of two or more polymers that have been blended Together to create a new material with different physical properties. Generally, There are five main types of polymer blend: thermoplastic–thermoplastic blends; Thermoplastic–rubber blends; thermoplastic–thermosetting blends; rubber–Thermosetting blends; and polymer–filler blends, all of which have been exten-Sively studied. Polymer blending has attracted much attention as an easy and Cost-effective method of developing polymeric materials that have versatility for Commercial applications. In other words, the properties of the blends can be Manipulated according to their end use by correct selection of the component Polymers [14]. Today, the market pressure is so high that producers of plastics need To provide better and more economic materials with superior combinations Of properties as a replacement for the traditional metals and polymers. Although, Plastic raw materials are more costly than metals in terms of weight, they are more Economical in terms of the product cost. Moreover, polymers are corrosion-resist-Ant, possess a light weight with good toughness (which is important for good fuel Economy in automobiles and aerospace applications), and are used for creating a Wide range of goods that include household plastic products, automotive interior And exterior components, biomedical devices, and aerospace applications [15]. The development and commercialization of new polymer usually requires many Years and is also extremely costly. However, by employing a polymer blending process – which is also very cheap to operate – it is often possible to reduce the time To commercialization to perhaps two to three years [16]. As part of the replacement Of traditional polymers, the production of polymer blends represents half of all Plastics produced in 2010. Today, the polymer industry is becoming increasingly Sophisticated, with ultra-high-performance injection molding machines and Extruders available that allow phase-separations and viscosity changes to be effec-Tively detected or manipulated during the processing stages [17]. Whilst this mod-ern blending technology can also greatly extend the performance capabilities of polymer blends, increasing market pressure now determines that, for specific Applications, polymer blends must perform under some specific conditions (e.g., Mechanical, chemical, thermal, electrical). This presents a major challenge as the Materials must often function at the limit of the properties that can be achieved; Consequently,

in-depth studies of the properties and performance of polymer Blends are essential.

2.2 Compatibility in Polymer Blends

In general, the compatibility between the polymer phases decides the properties of A heterogeneous polymer blend [18,19]. The interface between the polymer phases in A polymer system is characterized by the interfacial tension which, when Approaching zero, causes the blend to become miscible. In other words, if there Are strong interactions between the phases then the polymer blend will be miscible in nature. Large interfacial tensions lead to phase separation, with the phase-separated particles perhaps undergoing coalescence; this will result in an increased particle size and, in turn, decreased mechanical properties. The interfacial tension can be reduced by the addition of interfacial agents known as compatibilizers[20]; these are generally molecules with hydrophobic and hydrophilic Regions that can be aligned along the interfaces between the two polymer phases, causing the interfacial tension to be reduced and the compatibility of the polymer Blends to be increased. Compatibility results in a reduction of the dispersed particle size, an enhanced phase stability, and increased mechanical properties [21]. The Physical properties of miscible, compatibilized and uncompatibilized blends can Be characterized using techniques such as thermogravimetric analysis, dynamic Mechanical thermal analysis, and universal testing machines.[22]

2.2.1 Types of polymer blends:

1-Miscible polymer blend: Polymer blend, homogenous down to the Molecular level, associated with the negative value of the free energy of Mixing: $\Delta G_m \cdot \Delta H_m < 0$, and a positive value of the second derivative: $\partial^2 \Delta G_m / \partial \phi^2 > 0$ It is a single – phase structure , has properties of average Values between the values of properties of its components and has one Tg.

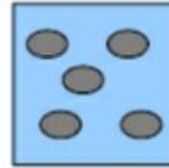
2-Immiscible polymer blend: A blend exhibits more than two phases. It Is a blend whose free energy of mixing; $\Delta G_m \cdot \Delta H_m > 0$ Usually, has two Tg's , since the two components are phase separated.

Scientists often measure the Tg of a blend to find out if it is miscible or immiscible. If two Tgs are found, then the blend is immiscible. If only one Tg is observed, then the blend is likely to be miscible.

3-Homologous polymer blend: Mixture of two or more fractions of the same



Miscible PB



Immiscible PB

polymer each of which has different molecular weight distribution.

4-Isomorphic polymer blend: Polymer blend of two or more different semi-crystalline polymers are miscible in the crystalline state as well as in the molten state.

5-Compatible polymer blend: An immiscible blend is called compatible if it is a useful blend wherein the inhomogeneity (caused by different phases) is on a small enough scale not to be apparent in use.

OR:

Blends that are miscible in a certain useful range of composition and temperature, but immiscible in others. Most compatible blends are immiscible and can be made compatible only by a variety of compatibilization techniques.

6- Polymer alloy: Immiscible, compatibilized polymer blend with modified interface and morphology.

2.3 The advantages of blending :-

A. Blending may improve resin or product performance by:

1. Producing materials having a full set of the desired properties at lowest cost.
2. Extending the engineering resins' performance by incorporation of less expensive polymers.
3. Improvement of specific properties.

- ◆ Brittleness : Toughening brittle polymers, thus eliminating the Need to use low molecular weight additives
 - ◆ Modulus & Dimensional Stability: Blending with more rigid And more heat resistant resin .
 - ◆ Improve Solvent and Chemical Resistance: Incorporation of Semicrystalline polymer into an amorphous resin.
 - ◆ Biodegradability: Incorporation of a biodegradable resin
 - ◆ Blending makes it possible to produce integrated multi-layer Structures.
4. The blending technology makes it possible to rebuild high molecular Weights of partially degraded polymers, thus to produce high performance Articles from the plastics waste.

B. Blending may lead to improved processability:

1-Process the high Tg resin at temperatures well below the thermal Degradation limit: Incorporation of a miscible resin with a lower glass Transition temperature (Tg) (e.g., PS/PPE blends).

2-Blends having a controllable degree of strain hardening (SH):

Blending with resin that either by itself shows high (SH) (e.g., LDPE in Blends with another PO), or when reactively blended forms long chain Branches (e.g., PS in blends with PO). These materials show better Processability in technologies where the extensional flow field is Important, viz., film blowing, blow molding, wire coating, foaming, etc

2.4 Materials

2.4.1 Low-density polyethylene(LDPE)

Low-density polyethylene (LDPE) is a thermoplastic made from the monomer ethylene. It was the first grade of polyethylene, produced in 1933 by Imperial Chemical Industries (ICI) using a high pressure process via free

radical polymerization.[23] Its manufacture employs the same method today. The EPA estimates 5.7% of LDPE (resin identification code 4) is recycled in the United States.[24] Despite competition from more modern polymers, LDPE continues to be an important plastic grade. In 2013 the worldwide LDPE market reached a volume of about US\$33 billion.[25] Despite its designation with the recycling symbol, it cannot be as commonly recycled as No. 1 (polyethylene terephthalate) or 2 plastics (high-density polyethylene).[26][27] LDPE is defined by a density range of 917–930 kg/m³. [28] At room temperature it is not reactive, except to strong oxidizers; some solvents cause it to swell. It can withstand temperatures of 65 °C (149 °F) continuously [28] and 90 °C (194 °F) for a short time. Made in translucent and opaque variations, it is quite flexible and tough. 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. The side branches mean that its molecules are less tightly packed and less crystalline, and therefore its density is lower. When exposed to consistent sunlight, the plastic produces significant amounts of two greenhouse gases: methane and ethylene. Because of its lower density (high branching), it breaks down more easily than other plastics; as this happens, Schematic of LDPE branching structure Properties the surface area increases. Production of these trace gases from virgin plastics increases with surface area and with time, so that LDPE emits greenhouse gases at a more unsustainable rate than other plastics. In a test at the end of 212 days' incubation, emissions recorded were 5.8 nmol g⁻¹ d⁻¹ of methane, 14.5 nmol g⁻¹ d⁻¹ of ethylene, 3.9 nmol g⁻¹ d⁻¹ of ethane, and 9.7 nmol g⁻¹ d⁻¹ of propylene. When incubated in air, LDPE emits methane and ethylene at rates about 2 times and about 76 times, respectively, more than in water.[29] The standard method to test plastic density is ISO 1183 part 2 (gradient columns), alternatively ISO 1183 part 1

(MVS2PROdensity analyzer.[30] Polyolefins (LDPE, HDPE, PP) are a major type of thermoplastic.[31] LDPE is widely used for manufacturing various containers, dispensing bottles, wash bottles, tubing, plastic parts for computer components, and various molded laboratory equipment. Its most common use is in plastic bags. Other products made from it include: Trays and general purpose containers Corrosion-resistant work surfaces Parts that need to be weldable and machinable Parts that require flexibility, for which it serves very well Very soft and pliable parts such as snap-on lids Six pack rings Juice and milk cartons are made of liquid packaging board, a laminate of paperboard and LDPE (as the waterproof Facial wash gel bottle made of LDPE inner and outer layer), and often with of a layer of aluminum foil (thus becoming aseptic packaging).[32][33] Packaging for computer hardware, such as hard disk drives, screen cards, and optical disc drives Playground slides Plastic wraps Plastic bags Plastic containers LDPE Pipes Housewares Battery cases Automotive parts Electrical components (PP)[31]



2.4.2 Polyvinyl chloride (PVC)

Polyvinyl chloride (alternatively: poly(vinyl chloride),^{[34][35]} colloquial: polyvinyl, or simply vinyl;^[36] abbreviated: PVC) is the world's third-most widely produced synthetic polymer of plastic (after polyethylene and polypropylene).^[37] About 40 million tons of PVC are produced each year.

PVC comes in two basic forms: rigid (sometimes abbreviated as RPVC) and flexible. The rigid form of PVC is used in construction for pipe and in profile applications such as doors and windows. It is also used in making plastic bottles, non-food packaging, food-covering sheets and plastic cards (such as bank or membership cards). It can be made softer and more flexible by the addition of plasticizers, the most widely used being phthalates. In this form, it is also used in plumbing, electrical cable insulation, imitation leather, flooring, signage, phonograph records,^[38] inflatable products, and many applications where it replaces rubber.^[39] With cotton or linen, it is used in the production of canvas.

Pure polyvinyl chloride is a white, brittle solid. It is insoluble in alcohol but slightly soluble in tetrahydrofuran.

PVC was synthesized in 1872 by German chemist Eugen Baumann after extended investigation and experimentation.[40] The polymer appeared as a white solid inside a flask of vinyl chloride that had been left on a shelf sheltered from sunlight for four weeks. In the early 20th century, the Russian chemist Ivan Ostromislensky and Fritz Klatt of the German chemical company Griesheim-Elektron both attempted to use PVC in commercial products, but difficulties in processing the rigid, sometimes brittle polymer thwarted their efforts. Waldo Semon and the B.F. Goodrich Company developed a method in 1926 to plasticize PVC by blending it with various additives,[41] including the use of dibutyl phthalate by 1933.[42]

Polyvinyl chloride is produced by polymerization of the vinyl chloride monomer (VCM), as shown.[43] About 80% of production involves suspension polymerization. Emulsion polymerization accounts for about 12%, and bulk polymerization accounts for 8%. Suspension polymerization affords particles with average diameters of 100–180 μm , whereas emulsion polymerization gives much smaller particles of average size around 0.2 μm . VCM and water are introduced into the reactor along with a polymerization initiator and other additives. The contents of the reaction vessel are pressurized and continually mixed to maintain the suspension and ensure a uniform particle size of the PVC resin. The reaction is exothermic and thus requires cooling. As the volume is reduced during the reaction (PVC is denser than VCM), water is continually added to the mixture to maintain the suspension.[37]

PVC may be manufactured from either naphtha or ethylene feedstock.[44]

The polymers are linear and are strong. The monomers are mainly arranged head-to-tail, meaning that there are chlorides on alternating carbon centres. PVC has mainly an atactic stereochemistry, which means that the relative stereochemistry of the chloride centres are random. Some degree of syndiotacticity of the chain gives a few percent crystallinity that is influential on the properties of the material. About

57% of the mass of PVC is chlorine. The presence of chloride groups gives the polymer very different properties from the structurally related material polyethylene.[45] The density is also higher than for these structurally related plastics. About half of the world's PVC production capacity is in China, despite the closure of many Chinese PVC plants due to issues complying with environmental regulations and poor capacities of scale. The largest single producer of PVC as of 2018 is Shin-Etsu Chemical of Japan, with a global share of around 30%.[44]

The product of the polymerization process is unmodified PVC. Before PVC can be made into finished products, it always requires conversion into a compound by the incorporation of additives (but not necessarily all of the following) such as heat stabilizers, UV stabilizers, plasticizers, processing aids, impact modifiers, thermal modifiers, fillers, flame retardants, biocides, blowing agents and smoke suppressors, and, optionally, pigments.[46] The choice of additives used for the PVC finished product is controlled by the cost-performance requirements of the end use specification (underground pipe, window frames, intravenous tubing and flooring all have very different ingredients to suit their performance requirements). Previously, polychlorinated biphenyls (PCBs) were added to certain PVC products as flame retardants and stabilizers.[47]



2.4.3 Magnesium oxideMgo

Magnesium oxide (MgO), or magnesia, is a white hygroscopic solid mineral that occurs naturally as periclase and is a source of magnesium (see also oxide). It has an empirical formula of MgO and consists of a lattice of Mg²⁺ ions and O²⁻ ions held together by ionic bonding. Magnesium hydroxide forms in the presence of water ($\text{MgO} + \text{H}_2\text{O} \rightarrow \text{Mg}(\text{OH})_2$), but it can be reversed by heating it to remove moisture. Magnesium oxide was historically known as magnesia alba (literally, the white mineral from Magnesia), to differentiate it from magnesia negra, a black mineral containing what is now known as manganese. While "magnesium oxide" normally refers to MgO, the compound magnesium peroxide MgO₂ is also known. According to evolutionary crystal structure prediction,[48] MgO₂ is thermodynamically stable at pressures above 116 GPa (gigapascals), and a semiconducting suboxide Mg₃O₂ is thermodynamically stable above 500 GPa.

Because of its stability, MgO is used as a model system for investigating vibrational properties of crystals.[49]

Pure MgO is not conductive and has a high resistance to electric current at room temperature. The pure powder of MgO has a relative permittivity in between 3.2 to 9.9 with an approximate dielectric loss of $\tan(\delta) > 2.16 \times 10^{-3}$ at 1 kHz.[50][51][52]

Magnesium oxide is produced by the calcination of magnesium carbonate or magnesium hydroxide. The latter is obtained by the treatment of magnesium chloride MgCl₂ solutions, typically seawater, with limewater or milk of lime.[53]

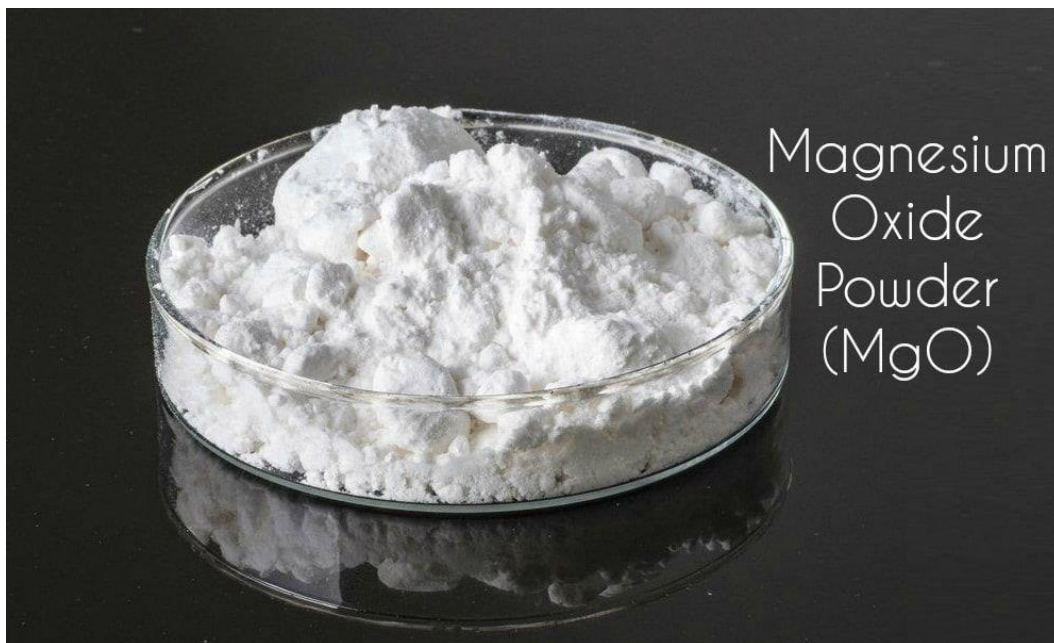
Calcining at different temperatures produces magnesium oxide of different reactivity. High temperatures 1500 – 2000 °C diminish the available surface area and produces dead-burned (often called deadburnt) magnesia, an unreactive form used as a refractory. Calcining temperatures 1000 – 1500 °C produce hard-burned magnesia, which has limited reactivity and calcining at lower temperature, (700–1000 °C) produces light-burned magnesia, a reactive form, also known as caustic calcined magnesia. Although some decomposition of the carbonate to oxide occurs at temperatures below 700 °C, the resulting materials appear to reabsorb carbon dioxide from the air.[54]

Magnesium oxide is used for relief of heartburn and indigestion, as an antacid, magnesium supplement, and as a short-term laxative. It is also used to improve symptoms of indigestion. Side effects of magnesium oxide may include nausea and cramping.[55]

In quantities sufficient to obtain a laxative effect, side effects of long-term use may rarely cause enteroliths to form, resulting in bowel obstruction.[56] Other As a food additive, it is used as an anticaking agent. It is known to the US Food and Drug Administration for cacao products; canned peas; and frozen dessert.[57] It has an E number of E530. It was historically used as a reference white color in colorimetry, owing to its good diffusing and reflectivity properties.[58] It may be

smoked onto the surface of an opaque material to form an integrating sphere.

It is used extensively as an electrical insulator in tubular construction heating elements. There are several mesh sizes available and most commonly used ones are 40 and 80 mesh per the American Foundry Society. The extensive use is due to its high dielectric strength and average thermal conductivity. MgO is usually crushed and compacted with minimal air gaps or voids. The electrical heating industry also experimented with aluminium oxide, but it is not used anymore. As a reagent in the installation of the carboxybenzyl (Cbz) group using benzyl chloroformate in EtOAc for the N-protection of amines and amides.[59]



Chapter three

Practical Part

3.1 Introduction

This chapter includes: -

- a- Materials used in preparing samples
- b- Preparation method the samples
- c- Tests

3.2 Materials Used

3.2.1 Materials

3.2.2 LDPE

LDPE used in the sample preparation process was obtained from the laboratories of the College of Materials Engineering, Department of Polymers and Petrochemical Industries with the properties maintain in Table (3-1).

Table (3-1) : Properties of the used LDPE.

| <i>Property</i> | <i>Data</i> |
|-------------------------|--------------------------|
| Color | white |
| Density | 917-930Kg/m ³ |
| Melt temperature | 65-90 C° |

3.2.3PVC

PVC used in the sample preparation process was obtained from the laboratories of the College of Materials Engineering, Department of Polymers and Petrochemical Industries with the properties maintained in table (3-2).

Table(3-2) : Properties of the used PVC

| <i>Property</i> | <i>Data</i> |
|----------------------------|-----------------------|
| Color | white |
| Density | 1.39g/cm ³ |
| Melting temperature | 200C° |

3.2.4 Mgo

MgO material used in the sample preparation process laboratories Faculty of Materials Engineering Department of Polymer and Petrochemical Industries with the properties maintained in table (3.3).

Table (3-3) :Properties of the used Mgo

| <i>Property</i> | <i>Data</i> |
|----------------------------|-----------------------|
| Color | white |
| Density | 3.6 g/cm ³ |
| Melting temperature | 2,852 C° |

3.3.1 Preparation the Samples

The sample preparation process was carried out by mixing the polymers together, meaning that LDPE granules were mixed with PVC granules in certain and specific proportions. three samples were prepared with different proportions of LDPE and PVC. The preparation process consists of three samples:

Table (3-4) :-All samples preparation process

| | |
|------------------|-----------------|
| 90 % LDPE | 10 % PVC |
| 70 % LDPE | 30 % PVC |
| 50% LDPE | 50 % PVC |

Where these proportions of LDPE and PVC were mixed together in a twin screw device and we got the samples below:

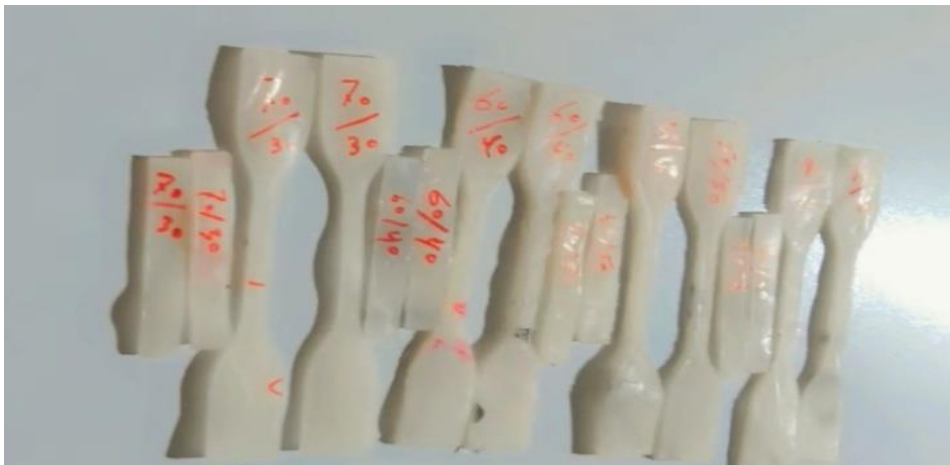


Figure (3-1) :- The final shape of the samples before adding nano-Mgo.

After completing the sample preparation process, we perform tests or laboratory tests on them to reach the best results.

3.3.2 Preparation after addition of nanoparticles (Mgo)

The sample preparation process was carried out by mixing the polymers together, meaning that LDPE granules were mixed with PVC granules in certain and specific proportions Mgo was added in proportions (1g). three samples were prepared with different proportions of LDPE/PVC and Mgo. The preparation process consists of three samples:

Table (3-5) :-All samples preparation process

| 90 % LDPE | 10 % PVC | (1g) Mgo |
|-----------|----------|----------|
| 70 % LDPE | 30 % PVC | (1g) Mgo |
| 50% LDPE | 50 % PVC | (1g) Mgo |

3.4 Tests

3.4.1 Tensile test

This test done according to ASTM D-638-02a by employing a Universal Tensile Test machine type (WDW/5E) as shown in **figure (3-2)**. To study the mechanical properties of pure (LDPE, PVC) . The test starts by applying specified load with 5 mm/min cross head speed.



Figure (3-3):-Tensile test

The examination process is carried out using a tensile test by taking a sample of the material with a specific section. It is attached at both ends to the tension device, and an increased tension is applied to it until the sample pieces are aligned. During operation, the tensile strength F and the elongation of the sample L are measured continuously. The mechanical stress on the specimen is calculated from the force and cross-section of the specimen before it is tested. During the examination process, both the sample cross-section and its effective length are usually measured, of which the stress and elongation are determined. In technical applications, the initial section is measured for ease and initial length, and the elongation values are recorded. The tensile strength is equivalent to the maximum tensile that the sample can withstand and is determined for its dependence on the sample section. After the tensile strength points are crossed, it is said about the material that it has failed or is disturbed, as the breakage of one of the parts cannot be avoided after the tensile strength point has been crossed.

3.4.2 Hardness test

Hardness of polymeric material is generally measured by two types of durometer type A and type D, this test is described in two similar ASTM methods D-1706 and D-2240, for measuring the indentation of materials ranging from soft rubber to hard rubbers and plastics. Shore D hardness device model (TH 210 FJ) as shown in **figure (3-3)** used to measure the hardness of PVC, LDPE and Mgo. Hardness instrument is containing needle placed in a position perpendicular to the sample and it is need (0.5 min) to read the value. Averages of three reading have to be taken at different points to get best accuracy.



Figure(3-4) : Diagram showing the Hardness test device

3.4.3 Differential scanning calorimetry (DSC) test

This device is used to measure the heat transitions, entropy, specific heat and enthalpy. This test was done according to ASTM D3418-03 using SHIMADZU-4 DSC-60 device. Samples of (PVC,LDPE) and (PVC,LDPE with Mgo) were in the form of powder weighing 0.004 g, then compress in pan and is placed in the device to conduct the examination. The specimen were tested under nitrogen gas and heating rate of 10 °C/min with heating range from RT to 220 °C.



Figure (3-5): (DSC) Test device.

Chapter four
Results

4.1 Introduction :

This chapter includes the following sections :

1. Study the mechanical properties:

- A. Tensile properties for all samples.
- B. Hardness for all samples .

2. Study the thermal properties :

- C. DSC for all samples .

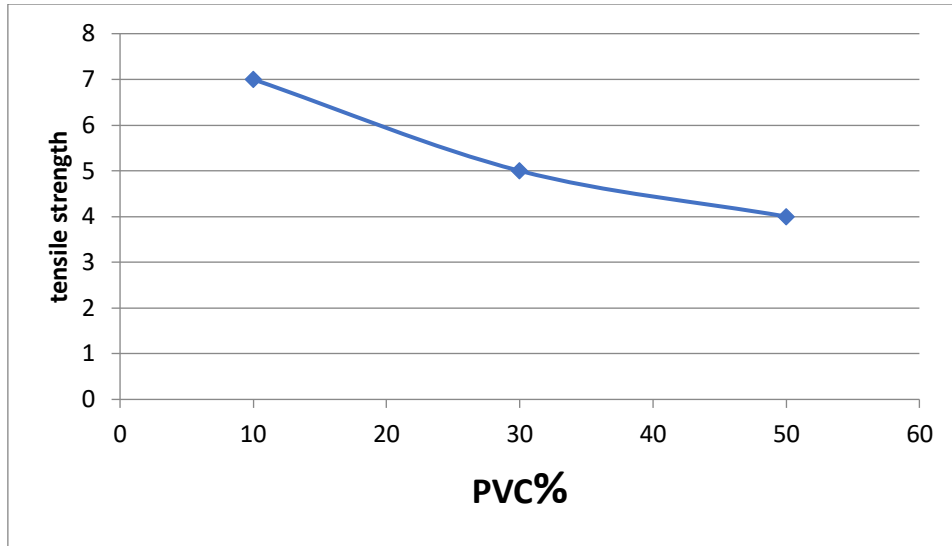
4.1.1 mechanical properties

1-Tensile

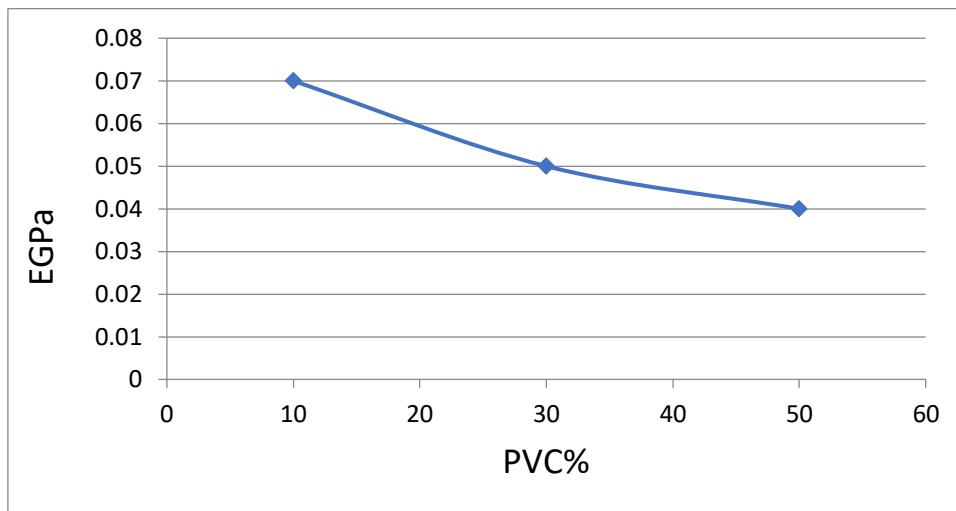
When PVC is added to LDPE, noticed a decrease in tensile strength When a ratio of 10-50. When adding Mgo at (1)%, noticed that the mechanical properties have improved Where the amount of tensile strength increased .The amount of tensile strength was increased when adding 1% of Mgo, and the modulus of elasticity (E) was also increased, so the elongation decreased. The reason for this is that the increase occurred as a result of adding Mgo nanoparticles, which in turn worked to blend LDPE and PVC. The hardness of the material also increased when adding Mgo nanoparticles, and this is an indication of the decrease in elongation .

Table (4.1) :- Table of polymer blend (LDPE, PVC) showing the values of tensile strength, modulus of elasticity and elongation.

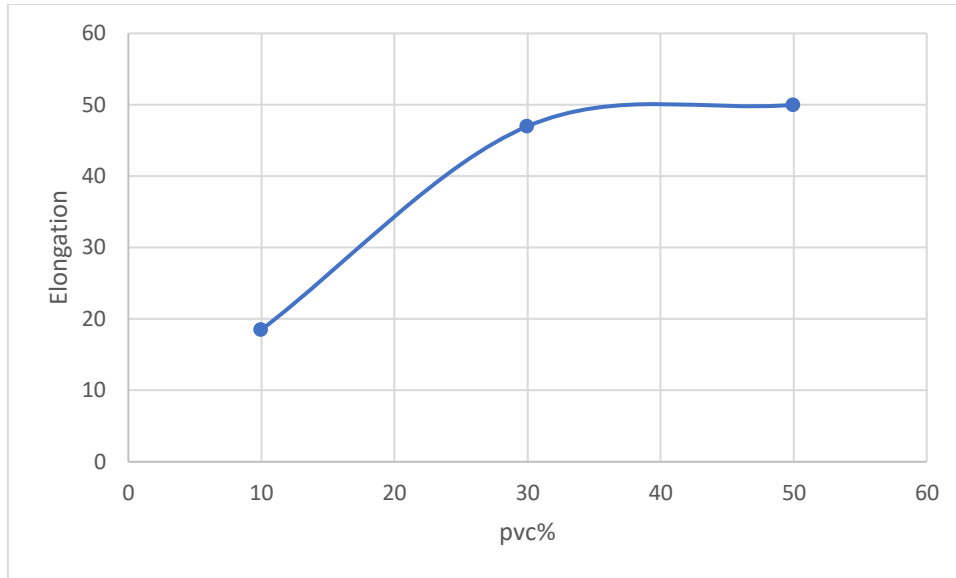
| Polymer blend | Tensile MPa | E GPa | Elongation% |
|------------------|-------------|-------|-------------|
| 90% LDPE/10%PVC | 7 | 0.07 | 18.5 |
| 70% LDPE/30% PVC | 5 | 0.05 | 47 |
| 50% LDPE/50% PVC | 4 | 0.04 | 50 |



4.1. tensile strength diagram for polymer blend



4.1.b Modulus of elasticity Diagram

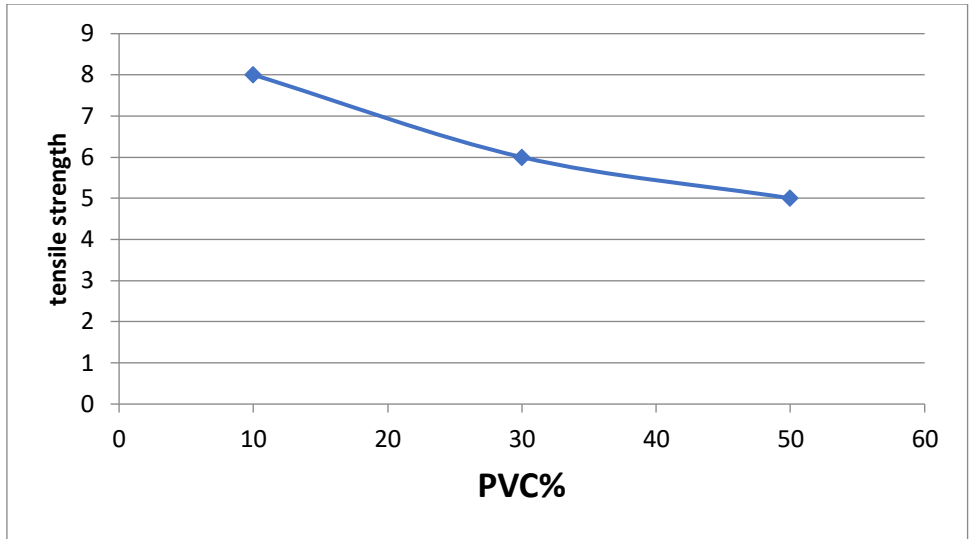


4.1.c Elongation Diagram

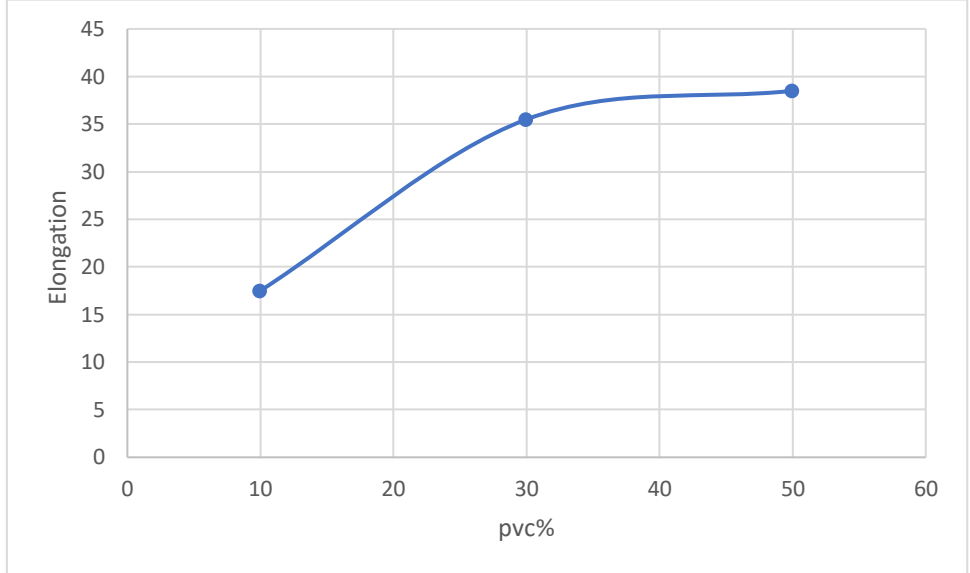
Figure (4-1):- mechanical properties by tensile test for polymer blend (LDPE, PVC) .

Table (4.2) :- Table of polymer blend (LDPE,PVC) with addition of Mgo nanoparticles.

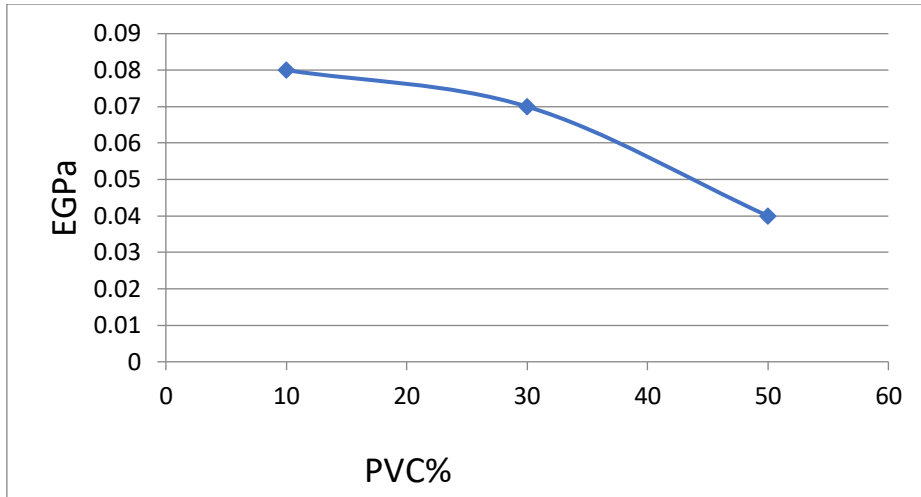
| LDPE/PVC | Mgo (g) | Tensile MPa | E GPa | Elongation |
|----------|---------|-------------|-------|------------|
| 90/10 | 1 | 8 | 0.08 | 17.5 |
| 70/30 | 1 | 6 | 0.07 | 35.5 |
| 50 / 50 | 1 | 5 | 0.04 | 38.5 |



4.2.a Tensile strength diagram with addition of Mgo nanoparticles Content.



4.2.b Elongation Diagram with addition Mgo Nanoparticle content.



4.2.c Modulus of elasticity Diagram With addition Mgo content.

Figure (4-2):-mechanical properties by tensile test for polymer blend (LDPE,PVC) After adding nanoMgo.

A. Hardness for all samples.

Table (4.3):- Table of polymer blend (LDPE, PVC) showing the values Average Hardness before adding MGO nanoparticles

| <i>Samples (LDPE/PVC)</i> | <i>Average Hardness</i> |
|---------------------------------|-------------------------|
| 90% LDPE /10% PVC | 37.8 |
| 70% LDPE /30% PVC | 32.7 |
| 50% LDPE /50% PVC | 28.3 |

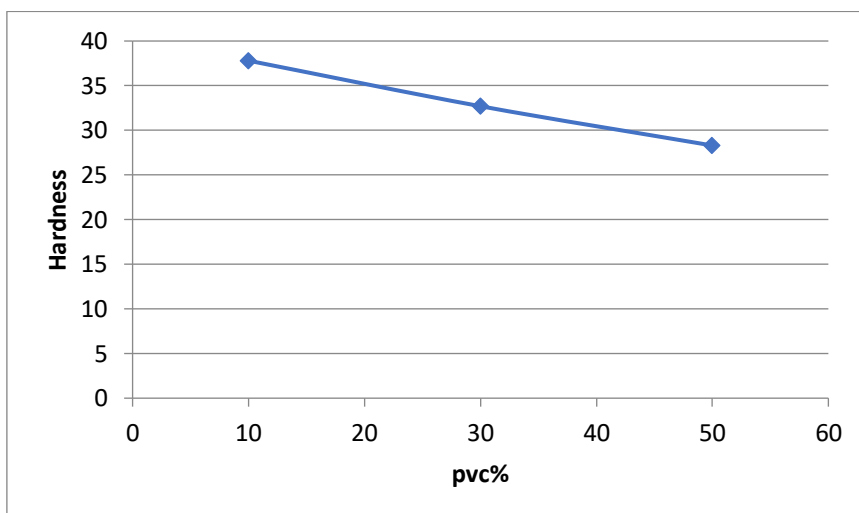


Figure (4-3):- Diagram showing the hardness curve of the polymer blend (LDPE/PVC) before adding MGO nanoparticles.

Table (4.4) :-Table of polymer blend (LDPE, PVC) showing the values average hardness after adding MGO nanoparticles.

| <i>Samples(LDPE/PVC)</i> | <i>MGO(g)</i> | <i>Average Hardness</i> |
|--------------------------|---------------|-------------------------|
| 90% LDPE /10%PVC | 1 | 39.9 |
| 70% LDPE /30% PVC | 1 | 38.9 |
| 50% LDPE /50% PVC | 1 | 38.6 |

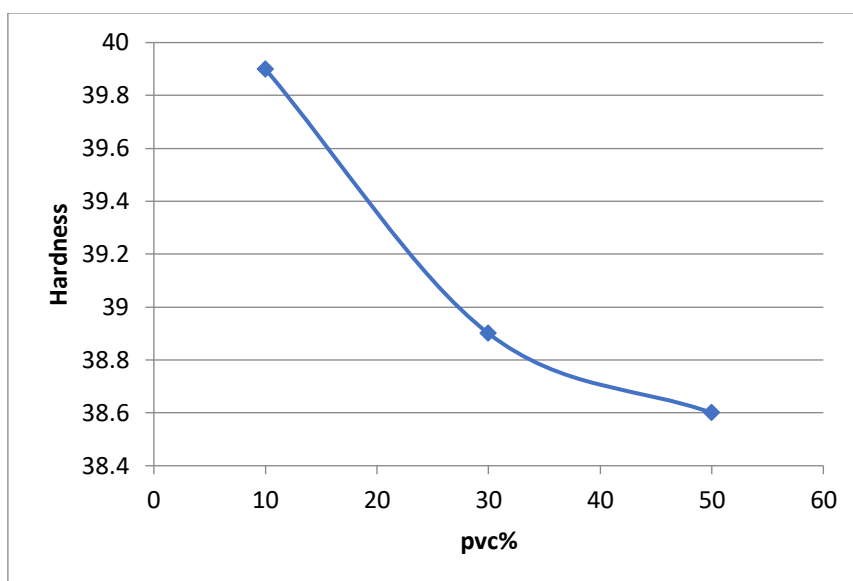


Figure (4-4) :- Diagram showing the hardness curve of the polymer blend (LDPE/PVC) after adding Mgo nanoparticles

When adding PVC to LDPE leads to a decrease in the hardness as a result of increasing the flexibility of the PVC and as a result of the incompatibility between the two polymers, as well as when adding Mgo it was found that the hardness increases because Mgo it has a higher hardness and thus improving the hardness of the polymeric mixture.

4.1.2 Thermal properties

A. DSC for all samples.

Mixing LDPE with PVC has very little effect on the melting temperature of the mixture. Where we note that the increase in the proportion of LDPE led to a decrease in the temperature of PVC in the mixture as well as a slight increase in the melting temperature of LDPE.

Table (4.5):- Table about thermal properties Shows the melting temperature of all samples without nano-Mgo.

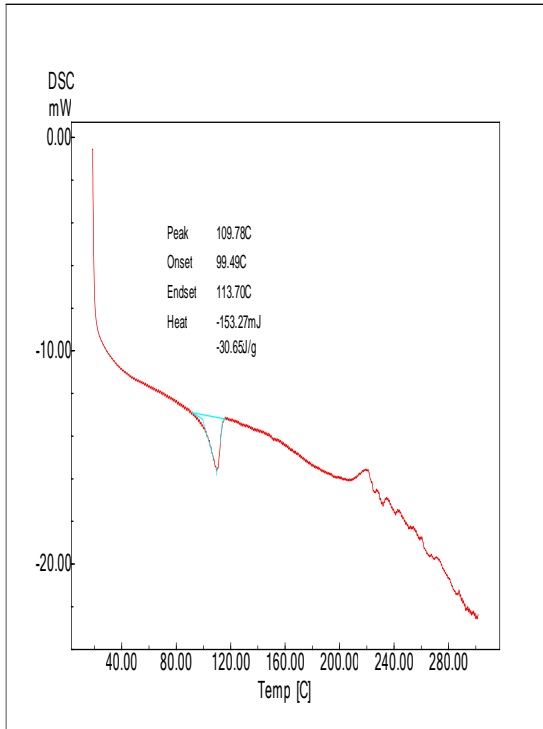
| Sample | Tm |
|--------------|--------|
| 90LDPE/10PVC | 109.78 |
| 70LDPE/30PVC | 109.46 |
| 50LDPE/50PVC | 108.68 |

Increasing the percentage of PVC led to an increase in the crystallization temperature, which means that the PVC led to the formation of larger crystals.

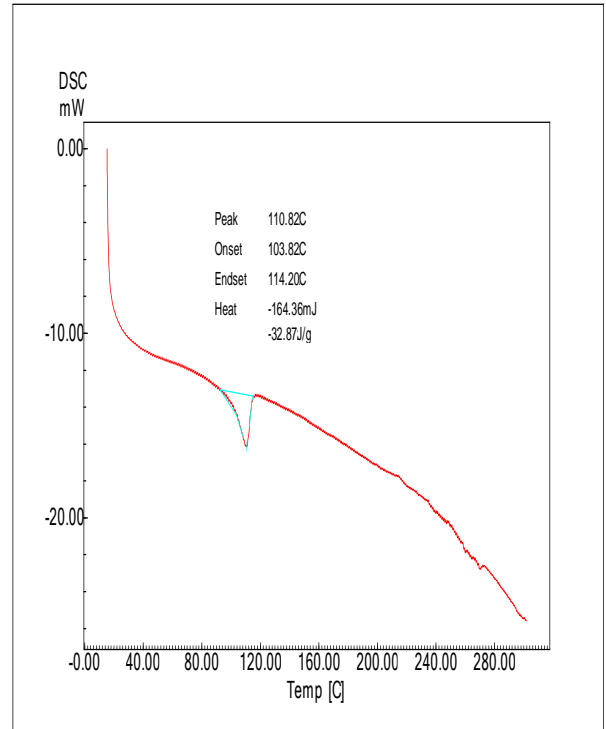
Table (4.6):-Table about thermal properties Shows the melting temperature of all samples After adding nanoparticles Mgo.

| Samples | Mgo (g) | Tm |
|--------------|---------|--------|
| PP/HDPE | | |
| 90LDPE/10PVC | 1 | 110.82 |
| 70LDPE/30PVC | 1 | 109.82 |
| 50LDPE/50PVC | 1 | 109.53 |

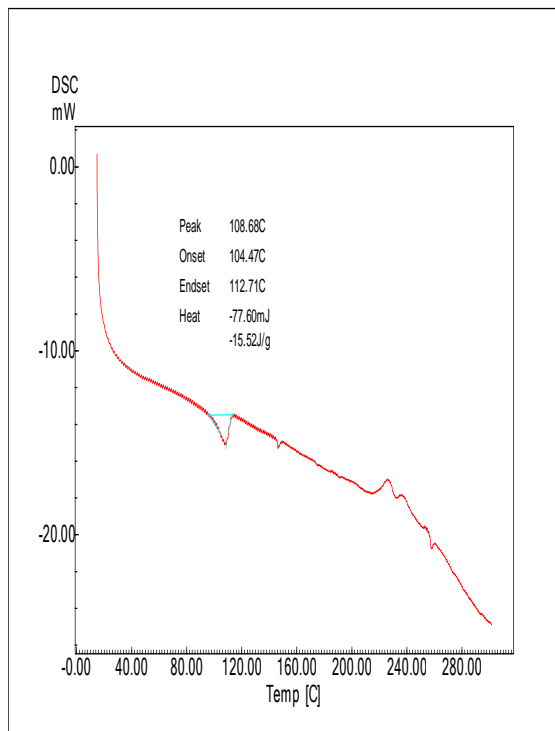
When adding Mgo to a mixture LDPE/PVC, it was found that the melting point improved slightly. The reason for this is the high melting point Mgo, which improves the material's resistance to heat.



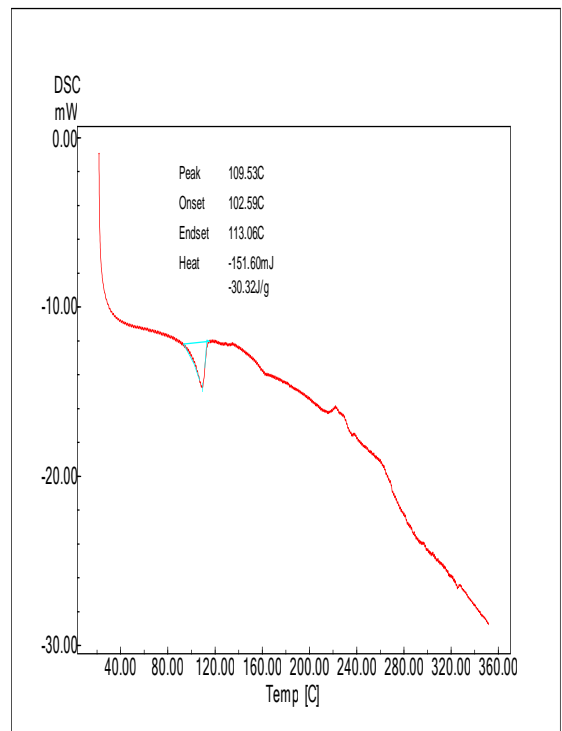
10-90



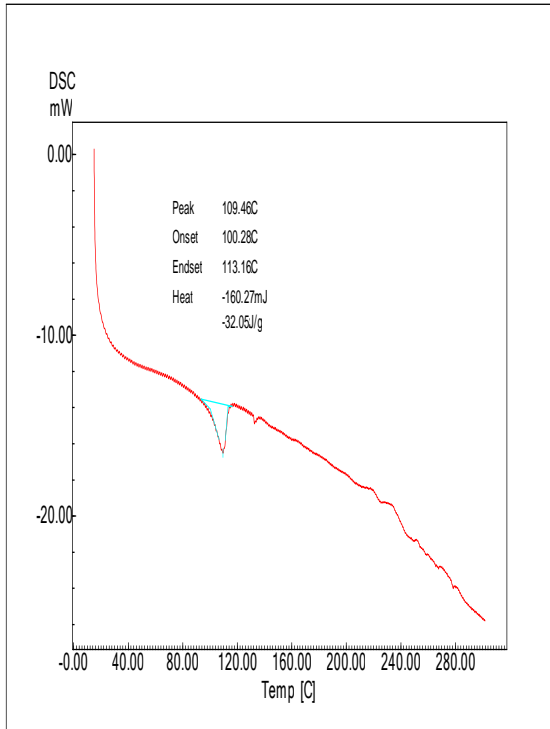
10-90 mgo



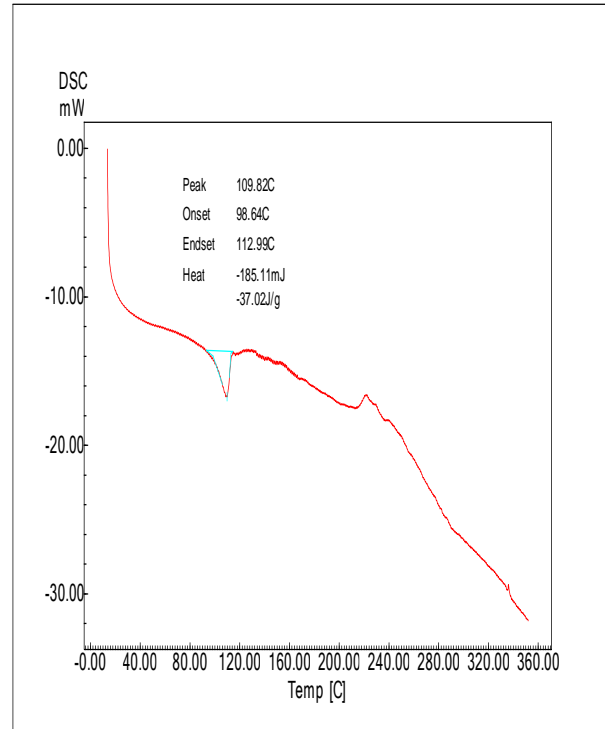
50-50



50-50 mgo



70-30mgo



70-30

Chapter Five
Conclusion

5.1 Conclusion:

From this work, it can be summarized the following conclusion:

- 1- It was found that adding nanoparticles to samples improved the mechanical and thermal properties .
- 2-It was found that adding nanoparticles (Mgo) to the mixtureLDPE/PVC at a rate of (1%) led to an increase in the tensile properties of the material.
- 3-As for the hardness test, it was found that adding nanoparticles (Mgo) at a percentage of (1%)to the mixtureLDPE/PVC led to an increase in the hardness of the mixture due to the high hardness of (Mgo).
- 4-adding Mgo to a mixture LDPE/PVC, it was found that the melting point improved slightly. The reason for this is the high melting point Mgo, which improves the material's resistance to heat

5.2 Recommendation

From the present study the following recommendations can be helpful for further studies :

- 1- Preparing samples of PP and PVC in different proportions
- 2- Add Nano (Tio)
- 3- The use of other tests TGA – SEM
- 4- Use electrical tests

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الخلاصة

مزيج البوليمر: - مزيج البوليمر هو مزيج من اثنين أو أكثر من البوليمرات التي تم خلطها معًا لإنشاء مادة جديدة.

تحتاج العديد من التطبيقات إلى أي خصائص محددة بغرض تلبية الحاجة إليها. من بين هذه الخصائص الخصائص الميكانيكية والحرارية، حيث أن البوليمرات عادة ما يكون لها خواص ميكانيكية وحرارية منخفضة مقارنة ببقية المواد، لذلك عادة ما نلجأ إلى استخدام مواد أخرى تضاف إلى البوليمرات، بما في ذلك المواد النانوية.

في هذه الدراسة تم تحضير ست عينات من البولي إيثيلين منخفض الكثافة والـ PVC بنسب مختلفة، ومن خلال الاختبارات التي أجريناها أجريت اختبارات (الشد، الصلابة، DSC).

من خلال اختبار الصلابة الذي أجريناه، عند إضافة PVC إلى LDPE يؤدي إلى انخفاض في الصلابة نتيجة لزيادة مرونة PVC ونتيجة لعدم التوافق بين البوليمرين، وكذلك عند إضافة MgO كان ذلك وجدت أن الصلابة تزداد لأن MgO لديها صلابة أعلى وبالتالي تحسين صلابة الخليط البوليمر.

من اختبار الشد، نلاحظ عند إضافة PVC إلى LDPE، نلاحظ انخفاضًا في مقاومة الشد عند نسبة 10-50. عند إضافة MgO بنسبة (1)٪، نلاحظ أن الخواص الميكانيكية قد تحسنت حيث زادت كمية مقاومة الشد.

تمت زيادة مقدار مقاومة الشد عند إضافة 1٪ من MgO، كما تمت زيادة معامل المرونة (E)، وبالتالي انخفاض الاستطالة.

والسبب في ذلك هو أن الزيادة حدثت نتيجة إضافة جزيئات MgO النانوية، والتي بدورها عملت على مزج LDPE و PVC. زادت صلابة المادة أيضًا عند إضافة جزيئات MgO النانوية، وهذا مؤشر على انخفاض الاستطالة.

من اختبار (DSC)، نلاحظ عند إضافة MgO إلى خليط LDPE / PVC، وجد أن نقطة الانصهار تحسنت قليلاً. والسبب في ذلك هو ارتفاع نقطة الانصهار MgO، مما يحسن مقاومة المادة للحرارة.