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Composite polymers; review

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الخلاصة

تضمن هذا المقال دراسة البوليمرات المشتركة ولماذا سميت بالبوليمرات المشتركة واصنافها والامثلة عليها. كما تضمن دراسة السبائك البوليمرية ومتى نطلق على البوليمرات بالسبيكة ،ومن ثم دراسة البوليمرات المتراكبة وماهي وكيف الحصول عليها ومتى نطلق على البوليمر بوليمر متراكب ،وما هو الكسر الحجمي والتعرف على المادة الاساس في المادة المتراكبة وما انواعها ،والى كم صنف تصنف المواد المتراكبة حسب المواد المدعمة ،وهناك عرض موجز عن الطرائق المستخدمة في انتاج المواد المتراكبة ولغرض معرفة اداء عمل المواد والاجزاء بالطريقة المتوقعة منها لهذا الغرض يجب التعرف على الفحوصات الميكنيكية وانواعها، ومن اهم الاختبارات اختبار الشد التي تحدد السلوك الميكانيكي للمادة في الاستخدام. واختبار الصلادة وتوجد العديد من طرائق قياس الصلادة تم التعرف عليها في هذا المقال .

Abstract

This article includes a study of copolymers, why they are called co-polymers, their classification, and examples of it. It also included the study of polymeric alloys and when to call polymers into the alloy, and then the study of composite polymers, what are and how to obtain them, and when do we call the polymer a composite polymer, what is the volumetric fraction and the identification of the base material in the composite and its types, and how classified according to the reinforced materials, and there is a brief presentation of the methods used in the production of the composite materials. For the purpose of knowing the performance of the materials and parts in the way expected from them, for this purpose, the mechanical tests and their types must be identified. Tensile strength and Hardness testing and several methods of measuring hardness are identified in this article.

Key Words :- Composite polymers , polymers alloys and Copolymer.

Introduction

The process that involves polymerizing monomer molecules of different materials is called co-polymerization, and the resulting polymer is called a (co-polymer), co-polymers whose molecules contain chains consisting of various repeating units. The polymer chains may contain two different repeating units as in the styrene-butadiene co polymer rubber , the styrene-methyl Methacrylate polymer or phenyl chloride-phenyl acetate co polymer. the polymeric chain may contain three different repeating units as in ABS plastic, which consists of acrylonitrile-butadiene-stearin copolymer in certain proportions.

Co-polymerization is gaining technological importance in controlling the mechanical properties of the polymer. Where flexibility and hardening can be controlled simultaneously, crack resistance, high temperature resistance and chemical resistance, such as solvents, can be controlled. Hence, copolymers are characterized by strength, durability, heat and solvent resistance [1].

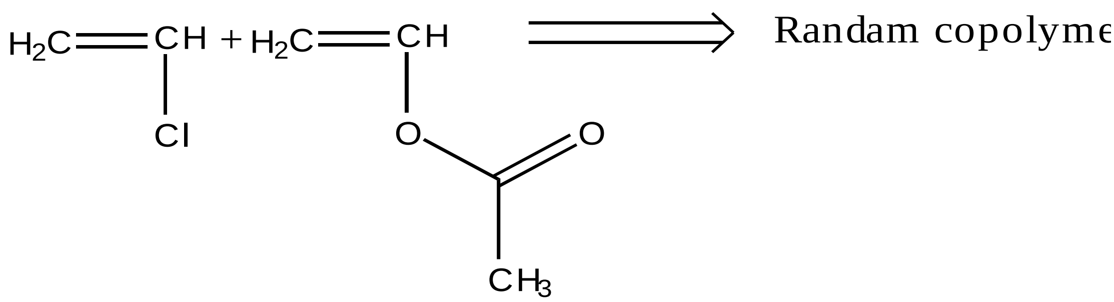
Classification and formation of copolymers[2-4]**:**

The copolymers have been classified into several classes according to how the polymeric chains are formed, that is, according to the arranging of the repeating units in the polymeric chains :-

1- Random copolymer 2- alternating copolymer

3- Block copolymer 4- Craft Copolymer

A—B—A—B—B—A—B—A—A—B—

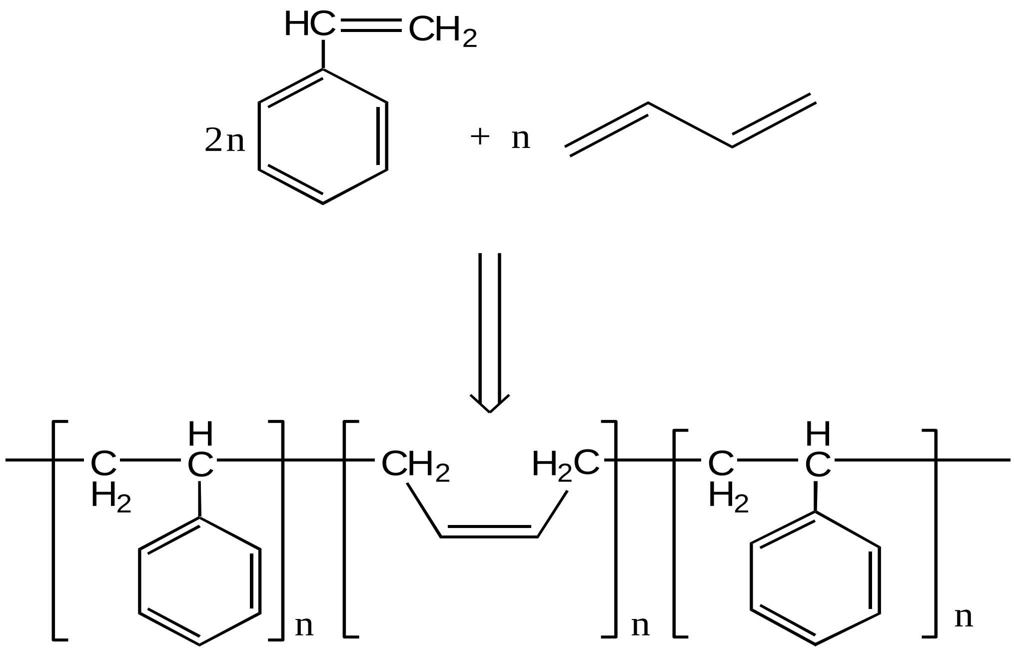


Alternating copolymer containing equal quantities of the two types of repeating units.

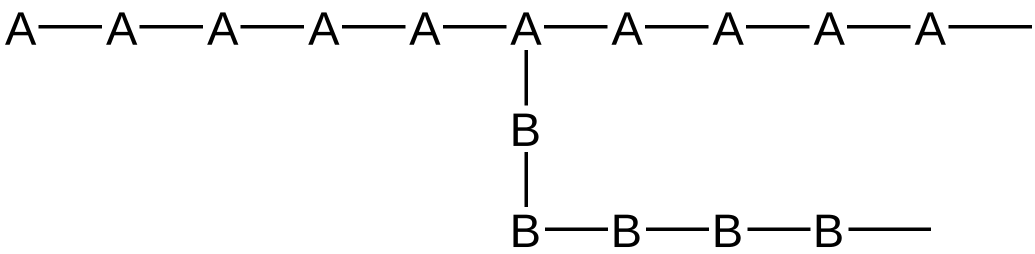
A—B—A—B—A—B—A—B—A—B—

The polymeric consists of blocks of the homopolymer polymer A connected with other blocks of the homopolymer B in this case, a clumping co-polymer (Block Copolymer) is obtained. An example of this type is a styrene-butadiene-styrene- copolymer

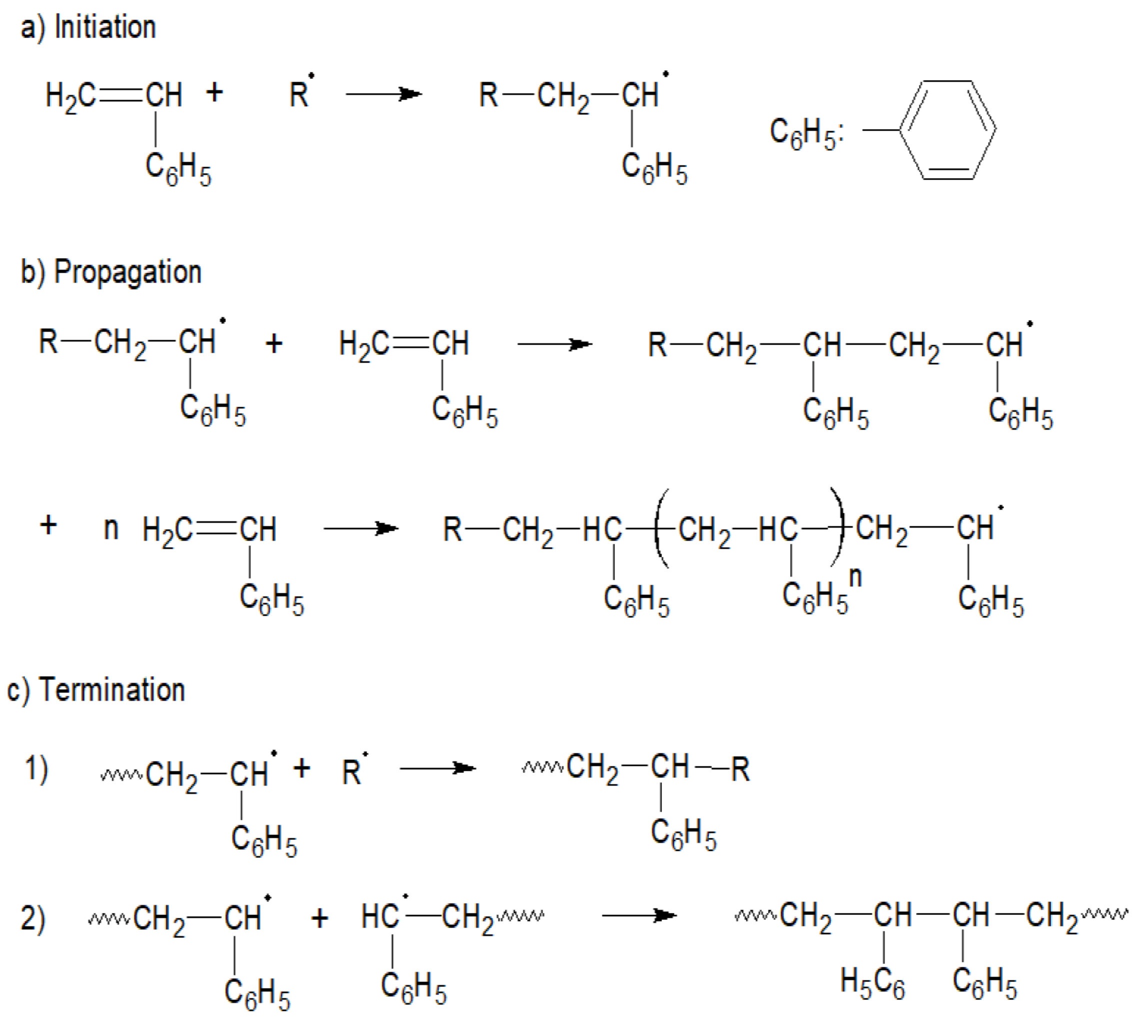
A—A—A—A—A—A—B—B—B—B—

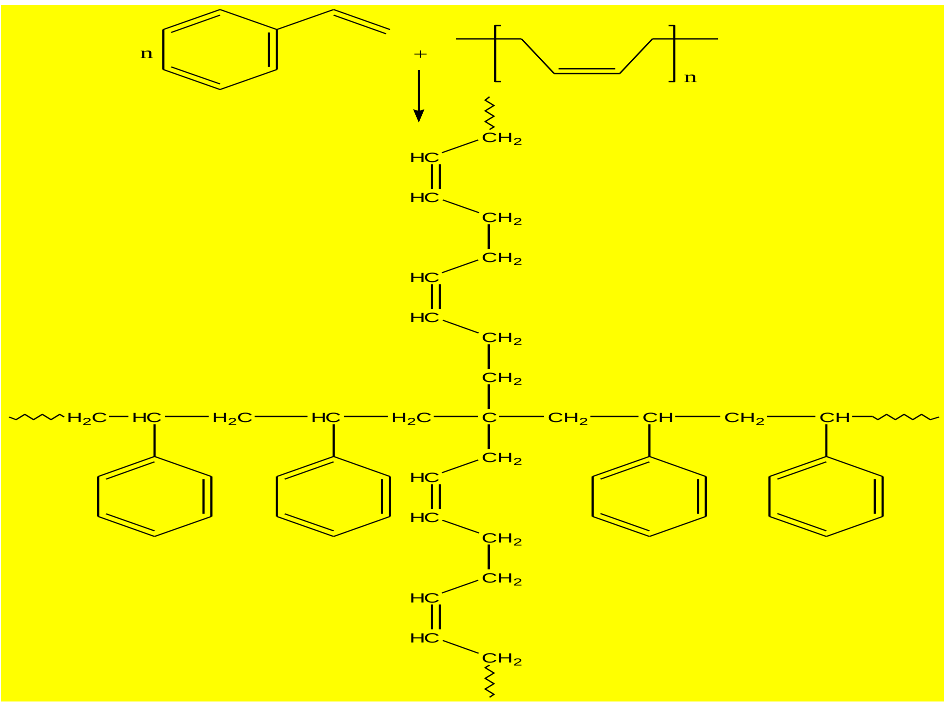


side branching of the polymeric chain as in grafted copolymers



Examples of co-grafted copolymers are High-impact polystyrene (HIPS) which is prepared by chain growth polymerization by forming free radicals of the styrenee monomer in the presence of a specific amount of butadiene polymer. As shown below**[5]**:


a) Initiation
b) Propagation
c) Termination
1)
2)



Polymeric alloys (IPN)

(Blends and Interpentrating Networks) are physical mixtures of single or combined polymers with different structure and internal composition and are produced with the aim of producing materials with new usability characteristics. For this reason, this process gives a wide rang for the introduction of the desired qualities in plastics and makes it sometimes an approach The qualities of engineering plastics in terms of quality and performance**[6-7]** .

The final characteristics of the polymeric alloy depend on a set of factors determined by the chemical nature of the components, the compatibility of the mixed polymers and their glass transition temperatures. The mechanical properties of the homogeneous alloy (single phase) depend on the properties of both polymers and their participation rate. In the case of the heterogeneous alloy, these characteristics depend on the nature of the continuous phase. The continuous phase in the alloy is known as the large matrix that contains inside it the second polymer.

Thermoplast, thermostat and elastomer polymers are used for these purposes. The single-phase composition is often observed in elastomer polymers, because both of the mixed components combine during the vulcanization process to form one phase.

In the case of interconnected networks (IPNS), the first network is prepared separately and then left to swell into the monomer of the second component, which polymerizes at a later stage, which leads to the formation of two networks that overlap with each other but remain independent of each other in terms of chemical composition**[7-8]**.

Homogeneous alloys are prepared from the thermoplast with the elastomer to anneal the thermoplast with the elastomer (if it is solid).

On the other hand, the preparation of heterogeneous alloys from a small amount of elastomer with a large mass of thermoplast improves the impact resistance of the latter and the addition of fibers to the thermoplast increases the hardness.

Alloys are prepared for many purposes, including making polymers heat resistant and making them easier to manufacture .

The properties of the alloy are determined by the nature of its phases, and in many cases it is possible to visually identify the presence of multiple phases in the alloy by its fuzzy appearance in its solid state. On the other hand, the transparency of the sample cannot be considered a definitive evidence of the compatibility of the mixed polymers**[9]**.

The appearance of the sample turbidity is the result of light scattering when there are multiple phases with different refractive indexes and the nature of the multiple phases in the alloy can be distinguished from the transition degree measurements

The homogeneous alloy (single phase) gives one degree of transmission, the alloy phase (single or multiple) depends on the thermodynamic coefficients of the components and the kinetic conditions. The alloy prepared from two different polymers is phase incompatible, however, the crystallized polymers are compatible if the mixture of their crystals is feasible. Compatibility also appears if there is a good interference force between the two materials, for example isotactic methylcrylate polymers are compatible with syndiotactic the difference in solubility as well as The poly acrylic acid is compatible with ethylene oxide due to the presence of hydrogen bonds between them, a complex component with an equivalent composition of both polymers, and compatibility means the mixability of the two materials in any proportion**[10]**.

It is not necessary for compatible polymers to have a single phase system, because the thermodynamic equilibrium may require a long period of time to reach a state of persistence due to the viscosity that leads to a slow permeability capacity. In contrast, a partial miscible system may last for a long time as a half-homogeneous phase. Therefore, homogeneous systems It does not mean that there is no compatibility between them most of the time**[11]**.

Polymeric alloys are prepared in two ways:

The first: by mixing the two molten polymers or their solutions with each other, in the molten method, the thermoplast polymer is taken, for example, in the form of a fine powder and mixed with the second polymer. The dissociation of the polymer and its liberation of free radicals may lead to grafting and crosslinking processes, heat dissociation can be reduced by using polymers of small molecular weights. In the field of using this method, it depends on the mixing conditions and the nature of the liquid melt.

The aqueous suspensions of both polymers can be mixed and this process is done at lower temperatures and dissociation rates compared to molten mixing due to the low viscosity of the suspension, and the internal structure of the suspended particles remains unchanged even after precipitation and after completing the process, the mixture is deposited to obtain the alloy**[12]**.

As for the solution method, both polymers are dissolved in a good solvent, then the solutions are mixed in the required proportions. A high homogeneous mixture can be obtained in this way if the polymers are compatible on the other hand, the incompatible polymers separate from each other after the solvent has removed from them.

Second: Dissolving the first polymer in the second monomer (or vice versa) and then polymerizing the monomer in situ.

Among the many uses in this field are polydienes systems with thermoplast monomers, as well as the use of crosslinked polymers and left to swell in the second monomer until they are saturated with it and then polymerize it afterwards to produce two networks intertwined with each other ((IPN) **[13]**.

Composite Materials

The word (composite) in the term comopsite materials indicates that two or more materials are combined to form a third substance of interest when fibers are added to plastics, for example, the resulting materials are called composites. The properties of these superimposed properties change depending on the nature of the support fibers, length, concentration and type of the fiber and the type of resin used in the material.

The Egyptians were using plywood when they realized that this wood could be rearranged to obtain high durability and resistance to thermal expansion, as well as its resistance to swelling resulting from moisture absorption**[14]**.

Many new technologies require materials with a rare set of properties that cannot be found in conventional metal alloys, ceramic or polymeric materials. This is true for materials that are adopted in aerospace applications for example

Aircraft engineers are constantly searching for structural materials that are low in cost, strong and tough, resistant to shock and scraping, and do not quickly wear out over time. Composite polymers can be classified broad classifications, for example the classification according to the reinforced material or substrate, as shown in Figure (1)

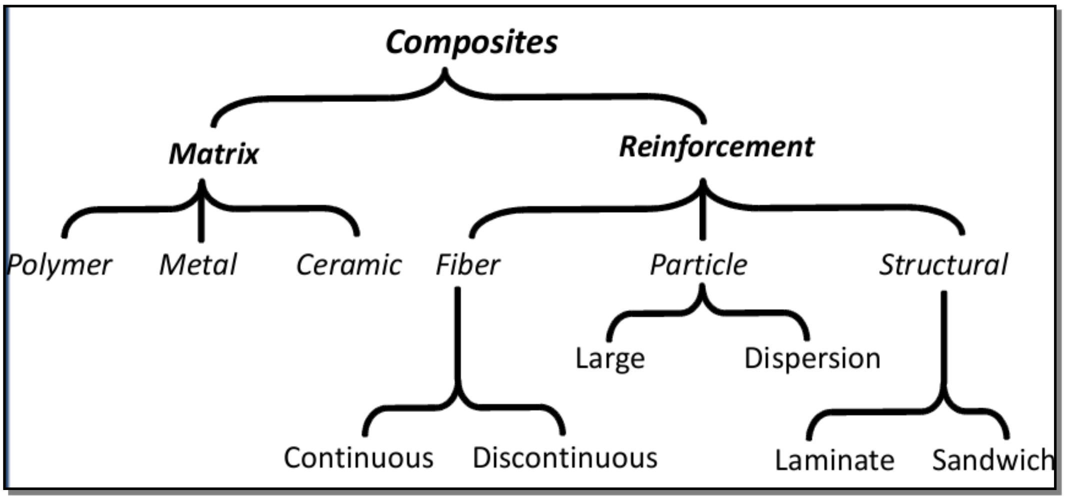


Figure (1): Classification of composite materials

The final properties of the fiber reinforced compound are

defined as**[15]**:

1- The type of fiber

2- Base material

3- Fiber orientation

4- Fiber material

Volume Fraction[16]

It is one of the important topics that should be studied, as it is known as the relative quantity of the various components in the composite material, and is usually expressed as the ratio of the size of the support to the total volume of the combined materials. It is difficult during manufacture to measure the size of the components, while measuring their weight is easier, so the use of weight fraction is also common. In rare circumstances when the density of materials is close, the measurement of the volumetric fraction and the weight fraction will give different values.

$\Phi = 1 / (1 + (1-\Psi) / \Psi). \rho f / \rho m$ ……………

whereas :

Φ: volumetric fraction of the fibers in the composite material.

Ψ: the gravitational fraction of the fibers in the composite material.

ρm, ρf: the density of the fiber and the substrate, respectively (Kg / m3).

The components of the composite material[17]

1- Matrix material

The base material gives the final shape to the composition of the composite and the base material can be classified according to the type of material, which are polymeric, mineral, ceramic and carbon materials. In general, minerals and polymers are used as the base material to obtain desirable polymeric properties. To improve fracture toughness.

Finally, a material with a polymeric basis can be defined as a homogeneous resin or a polymeric material in which fibers or particles are immersed to form a composite material**[18]**.

Polymers Matrix Composite

Polymers are not used in high temperature applications due to their poor thermal stability. Some plastics may be within the temperature range (100-200 ° C).
This type of composite is one of the most popular types compared to metal or ceramic based composites in commercial applications, as this type of composite represents 90% of all the composites.
This type is also known as polymers or fiber-reinforced plastics. These materials use a polymeric-based resin as the base material, and various types of fibers such as glass and melamine are used as support materials**[19]**.

The properties of any polymer based compound depend on:

1- The properties of fibers or microelements
2- Properties of the resin
3- The ratio of fiber or fines to resin (volume fraction of fibers or fines)
The mechanical properties of the fibers are generally higher than the mechanical properties of the resin, so if the volumetric fraction of the fibers is high, the mechanical properties of the composite are increased.
4-The orientation and geometric shape of the fibers inside the composite material.The role of the fibers in supporting the host medium
Is at its greatest value when they are all aligned parallel to the composite external stress axis. Figure (2) shows the drag stress parallel and perpendicular to the direction of the fiber**[20-22]**.

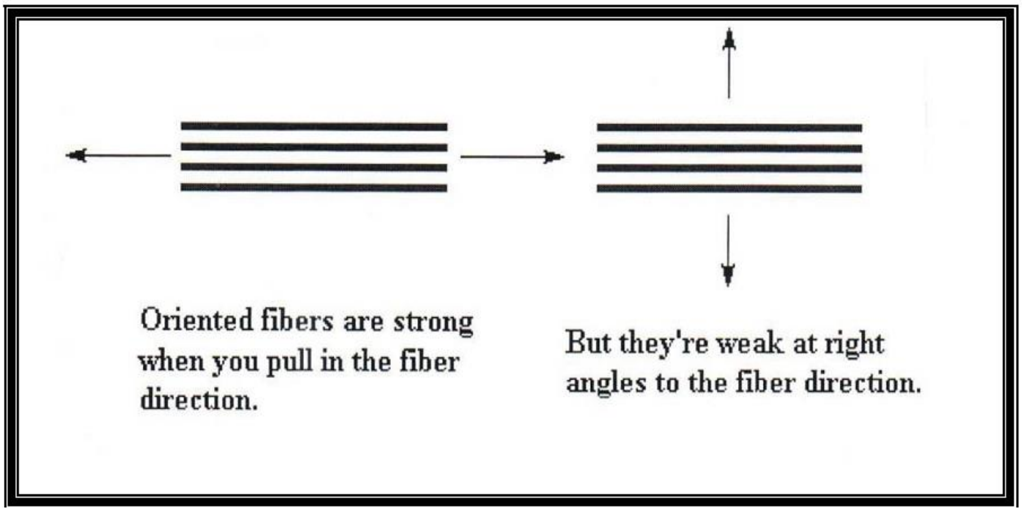


Figure (2) Draw strain parallel and perpendicular to the direction of the fiber.

1- Metal Matrix composites

Metal-based composites can be obtained either by using a liquid phase such as Spray Deposition, or by solid-state processes such such as powder techniques. The most popular types are aluminum-based composite, fiber-reinforced titanium alloys and magnesium alloys reinforced with silica granules. The first type (aluminum) is the most common due to its cost and ease of manufacture.
Fiber reinforcement improves the mechanical properties of metals, for example carbon fibers increase the strength and durability of soft metals such as lead**[23]**.

2- Ceramic matrix composites[21-23]:-

Ceramic-based composites are used in high-temperature oceans. This type of coposite is somewhat wide range including

crystalline ceramics, glass ceramics, inorganic silica and carbon.

The support may include carbides and oxides, and one of the most important properties of the ceramic-based compounds, high electrical resistance, stable (chemically, thermally).
and it has a high melting point (1200 -3500 ° C).

Reinforcement Materials

The support materials are very important for the composite material as it gives all the necessary strength and toughness to the composite. And increase the damping (the damping increases with the increase in the filler level in the composite material)
The composite materials are classified according to the material used in the reinforcement into**[24]**:

1- Composites Particulated Materials

2- The composites reinforced fibers
3- Laminated Composites

Some methods of producing polymeric composite materials with gradient properties

The following is a brief presentation of the methods used in the production of polymeric composite materials with gradient properties:

1- Gravity casting method
2- Method of plumbing under the influence of Centrifugal Casting
3- Pressing method
4-Ultra Violet photo polymerization method

Mechanical examinations

The aim of each examination is to ensure that the work of materials and parts performs in the manner expected of them. For this purpose, there are mainly two types of mechanical tests, namely**[25]**:

1- Destructive Test
2- Non-destructive test

1-Destructive test: It is the test that destroys test pieces during the inspection process, and this is why it is called the destructive test. Tensile test,Compresion test, Tortion test,Bending test and Hardness test and other kinds of tests

2-Non-destructive test:

Non Destructive Tests, are those tests that are normally used to check the adequacy of the materials and parts for their designed purposes. NDT involve all possible testing procedures that can be implemented to check the materials parts without neither being damaged nor affecting their service, nor the serving life, the most common methods used in the examination are: Visual Technique, Liquid Penetrate, Test Ultrasonic, Impact Strength, Pulse Velocity, and Vibration damping techniques. Technique Some of the necessary tests can be identified to determine the durability of the polymeric composite**[24-25]** .

Tensile Test[26]

To know accurate values of the mechanical properties of engineering materials, including composite materials, it is by following the tensile test, which is one of the important mechanical tests in which many information can be known that determine the mechanical behavior of the material in use.

The shape and values of the stress-strain curve depend on many factors, including those related to the conditions of the test, such as temperature, strain rate, and the stress position of selection. With a rise in temperature, the stress-strain curve changes toward the rubbery behavior, and with lower temperature the curve changes toward the brittle as well as brittle behavior In Figure (3)

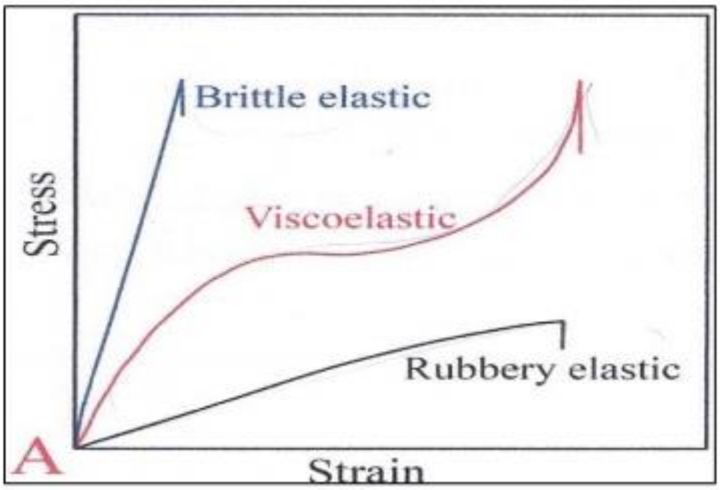


Figure 3: The stress-stress curves of polymers

2- Hardness Test[28-29]

The hardness property in general determines its resistance to scratching, cutting, wear, indentatation, penetration, and mach inability. The hardness of the material depends on the type of bonding force between the particles or atoms, on the type of surface, temperature, and conditions. There are many methods of measuring hardness, including: Brinell hardness the penetration tool is in the shape of a ball of carbide or steel.
Vickers hardness the penetration tool is a pyramid of diamond.
The hardness of Rockwell (R0ckwell) is a diamond cone penetration tool.

- Shore Sclerscope hardness measured by ball bounce.
- Shore Duometer which divides into Shore A, ShoreC, and Shore D and the Penetration tool is a needle.

Barcol method.

The hardness value gives an indication of the resistance (Index of Strenght) and the coherence of the structure. The hardness is associated with the mechanical resistance of the material, as it is in most cases the material of low hardness and low yield strength**[30]** .

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