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Characterization of Polyester-Data Palm Fibers Nanocomposite

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DR. ATHEER ALMASRI

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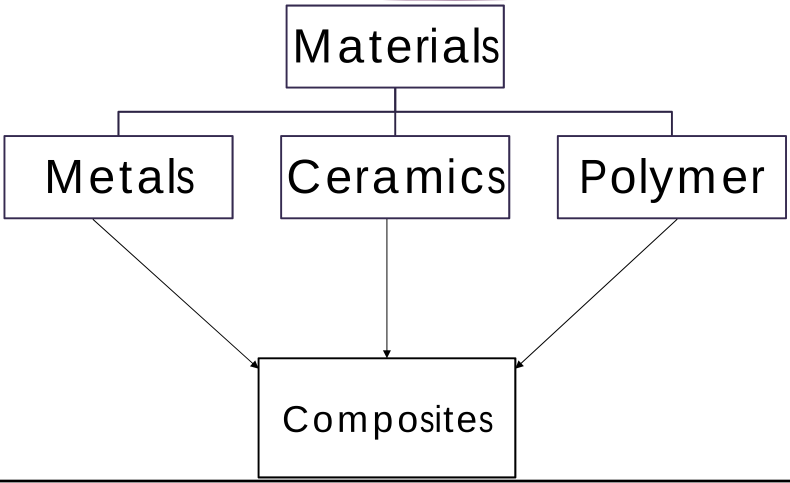
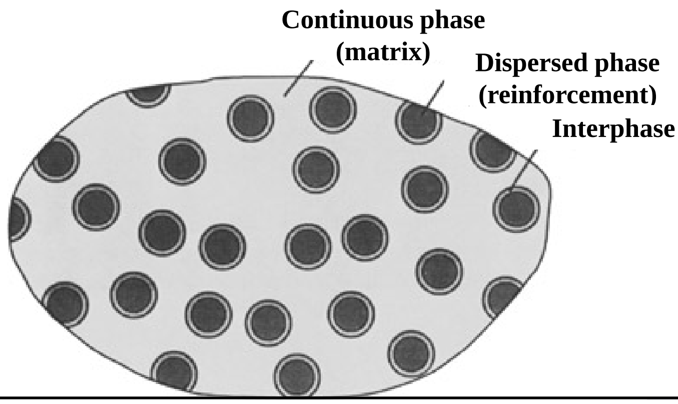
Introduction



Introduction

- **Composite materials** are formed by the combination of two or more materials, in which one of the material is called the **reinforcing phase**, is in the form of particles, sheets, or fibers, and is embedded in the other material called **matrix phase**.

- The **reinforcement phase** of composite can exist in different sizes such as **micro** and **nano** sizes.



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Objectives

- To study the effect of adding date palm leaves fibers on the morphology of polyester by using **mechanical properties**.
- To study the effect of adding date palm leaves fibers on the morphology of polyester by using **thermal Properties**.

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Nanocomposite Materials

- **Nanocomposites** are composites in which at least one of the constituent phases has one dimension **less than 100 nm**.
- The nanocomposite **performance depends on** a number of nanoparticles features such as the **size**, **aspect ratio**, **specific surface area**, **volume fraction** used, **compatibility** with the matrix and **dispersion**.

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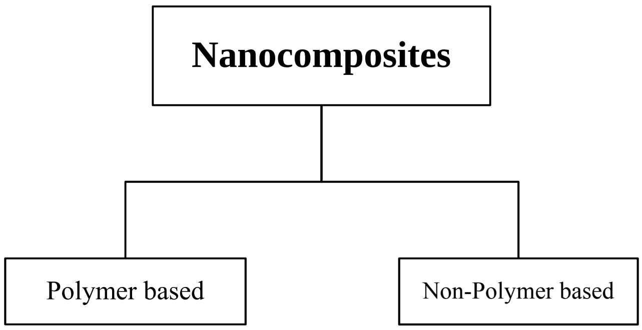
Nanocomposite Materials



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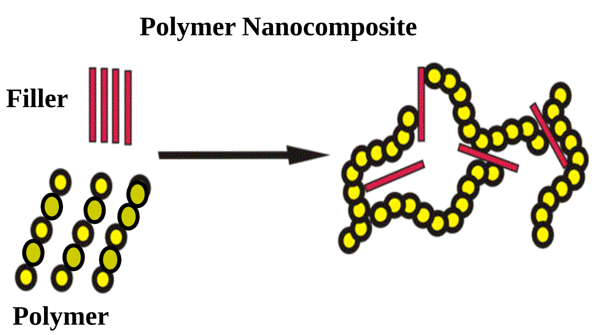
Polymer Nanocomposite

▶ **Advantages of using Polymers:**

- Low cost.
- Reproducibility.
- Easy processing.



▶ **Targets of Polymer Nanocomposite:**

Improve mechanical property like stiffness, toughness, strength, and thermal insulation when we compare it with pure polymers.

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Fillers

- **Definition:**

  - Substances that added to a product to **improve** it to have a desire result. The filler also can be defined as a piece used to cover or fill space between two parts of structure.

  - Fillers in the matrix of a composite is known as the **disperse phase**.

- **Classification:**

Fillers
- **Organic Filler** — ex: Carbon nanotube
- **Inorganic Filler** — ex: **Natural Filler such as** Data Palm fiber

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Polyester

- **What is Polyester?**

- Polyester is one of the category of polymers that contain the **ester functional group** in their main chain.

- Depending on the **chemical structures**, polyester can be a thermoplastic or thermoset.

- **Advantages:**

- Low cost.
- Ease of handling.
- Dimensional stability.
- Good mechanical properties.

Polyester Synthesis:

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- **A wide range of reactions to obtain the polyester;**

  - **Esterification** of carboxylic acid.

  - **Polycondensation** reactions.

Polyester Hardner:

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- **Cure** to solid when the hardener is added .

- **Curing** : creates a *chemical reaction* that allows the resin to change from a liquid to a solid state.

- **Methyl Ethyl Ketone Peroxide (MEKP)**

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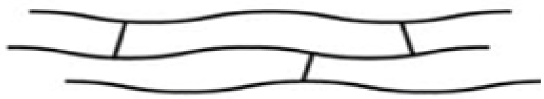
Unsaturated Polyester Resin :

- The polymerization reaction is **initiated via** a peroxide, typically methyl ethyl ketone peroxide (MEKP).



Cross-linked Polyester Matrix

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Date Leaves Palm Fibers

- The **natural fibers** as reinforced material for polymer composites has exhibited positive effects in their mechanical behavior compared to the pure matrix and encouraging results compared to the synthetic fibers as reinforced material.

- **There are several factors related to the natural fibers such as:**

- The interfacial adhesion. - The strength. - Moisture absorption.
- Impurities. - Orientation . - Volume fraction.

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Date Palm Fibers Preparation

1- Sieves Analysis

Particle size may be specified by quoting the size of two screens , one through which the particles have passed and the other on which they are retained.

- From **> 2 mm** to **350 µm**

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Date Palm Leaves Fibers Preparation

2- Size reduction is process to reduce **large solid** particles masses **into small** unit masses.

- **Equipment used:**
  - Planetary Ball Mill.

From **350 µm** to less than **100 nm**

- **Important Parameters:**

- Revolution speed or rotational speed at a constant speed ratio.
- Milling time.
- Filling ratio of milling balls or the number of milling balls at constant chamber size.
- Filling ratio of grinding material or ball to powder ratio.

Processing Methods

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- Creating one universal technique for making polymer nanocomposites is difficult **due to the** physical and chemical differences between each system available to researchers.

Processing → Structure → Properties → Performance

Processing Methods

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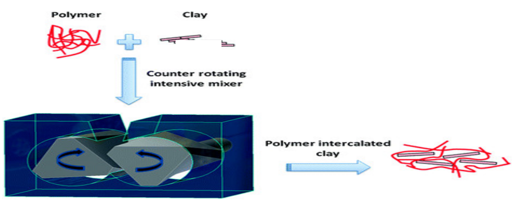
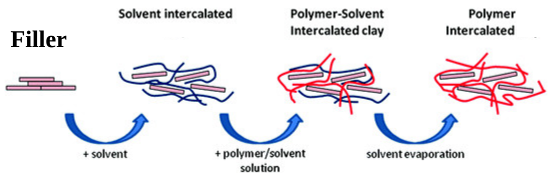
- There are a lot of processing methods used to make nanocomposites such as:

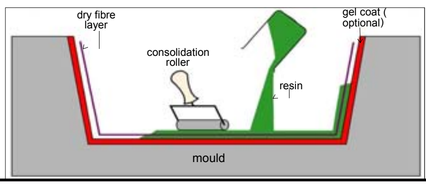
- Melt Interaction.



- Exfoliation-Adsorption.



- Hand lay-up.



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Processing Methods

- Our processes consist of the following equipment:

  - Magnetic Stirrer.

  - Sonicator.

  - Drying Oven.

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Processing Methods

1- Magnetic Stirrer.

Magnetic stirred is a devices that have been using in the laboratory in industrial and researches. It is a device that employs a rotating magnetic field to cause a stirred bar goes inside the liquid to spin very fast.

Processing Methods

2- Sonicator.

- Ultrasonicator is a device that use a process of **ultrasound** (approximately from 40 to 400 kHz) and ordinary tap water or sometimes appropriate solvent to clean the items.

- Ultrasonication is commonly used in nanotechnology for evenly **dispersing** and **mixing** the **nanoparticles** in liquids

Mold

- According to ASTM D508

Procedure of Preparation Samples

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The procedure as follow:

1- Weighing Sample.

2- Magnetic stirred for half an hour and continually mixing at 75 °C .

3- Sonicator for also half an hour at 25 °C (room temperature).

4- Magnetic stirred again for half an hour.

5- Adding hardener (12 droplets).

6- Casting in the mold.

Procedure of Preparation Samples

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- **Samples Under Vacuum :**

The **second procedure** including the first three steps of the first procedure which are:

1- Weighing Sample.

2- Magnetic stirred for half an hour and continually mixing at 75 °C .

3- Ultrasonic cleaner for also half an hour at 25 °C (room temperature).

Then :

4- The sample was putt in a vacuum chamber for one day.

5- The sample was putt in an oven at 60 °C for 2 hours.

6- Adding hardener (12 droplets).

7- Casting in the mold.

Processing Methods

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5- Vacuum Chamber.

- The vacuum chamber is rigid and enclosure vessel from which air and other gases are removed by a vacuum pump or compressor.
- The removing of air results in low-pressure environment within the chamber, commonly called vacuum.

Processing Methods

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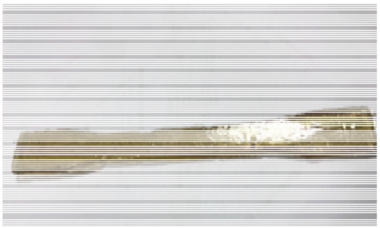
6- Drying Oven

This oven generally provide uniform temperatures inside the oven .

Samples



Mechanical Properties Test

- A tensile test, also known as tension test, is probably the most fundamental type of mechanical test you can perform on material.
- By pulling on something, you will very quickly determine how the material will react to forces being applied in tension.
- As the material is being pulled, you will find its strength along with how much it will elongate.

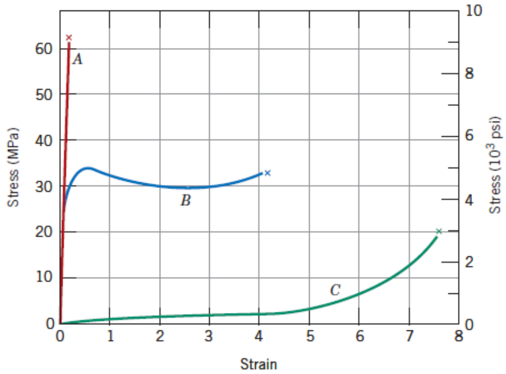
Mechanical Properties

- **Stress Strain Behavior:**

- Stress: $\sigma = \frac{F}{A}$

- Strain: $\varepsilon = \frac{\Delta l}{l_0}$

- Brittle (curve *A*).
- Plastic (curve *B*).
- Highly elastic (elastomeric) (curve *C*).



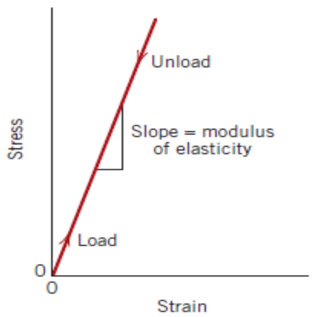
Mechanical Properties

- **Modulus of Elasticity:**

- Deformation in which stress and strain are proportional is called **elastic deformation**.

- The **physical meaning** of the modulus of elasticity is the stiffness or the material's resistance to elastic deformation.

$$E = \frac{\sigma}{\varepsilon}$$



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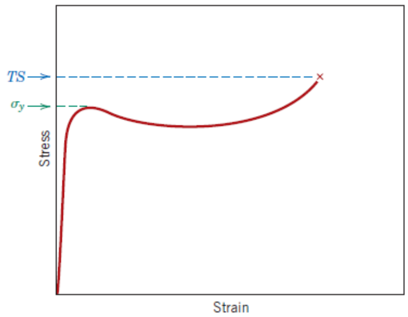
Mechanical Properties

- **Tensile and Yield Strength:**

  - **The yield point** is taken as a maximum on the curve, which occurs just beyond the termination of the linear-elastic region. The stress at this maximum is the yield strength (σ_y).

  - **Tensile strength (TS)** corresponds to the stress at which fracture occurs.

  - **TS** may be greater than or less than $\boldsymbol{\sigma_y}$.



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Mechanical Properties

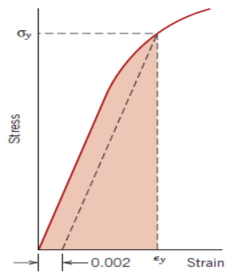
- **Resilience:**

is the capacity of a material to absorb energy during elastic deformation.

- The associated property is the ***modulus of resilience***, $\boldsymbol{U_r}$, *which is the strain energy per unit volume required to stress a material up to yielding point.*

- Definition of **modulus of resilience**: $U_r = \int_0^{\varepsilon_y} \sigma d\varepsilon$

  - for **linear elastic** behavior, $U_r = \frac{1}{2}\sigma_y \varepsilon_y = \frac{\sigma_y^2}{2E}$ incorporating Hooke's law



Mechanical Properties

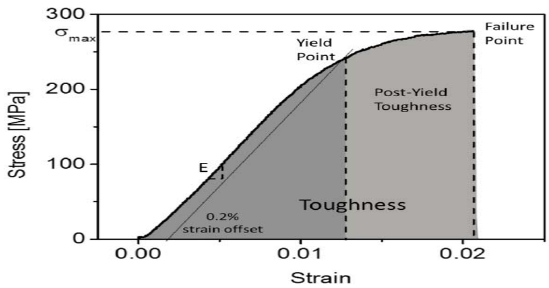
- **Toughness:**

is a measure of the ability of a material to absorb energy up to fracture.

- It is the **area under the curve** up to the point of fracture.

$$Toughness = \int \sigma d\varepsilon$$

- For the materials to be**tough**:
  it must display both **strength**and **ductility**.



Mechanical Properties

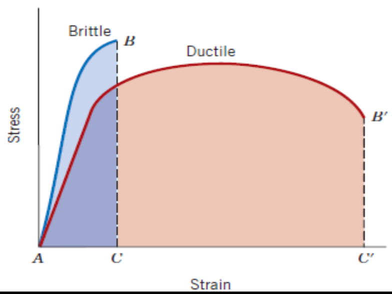
- **Ductility:**

is a measure of the degree of plastic deformation that has been sustained at fracture.

- Ductility may be expressed **quantitatively** as either ***percent elongation*** or ***percent reduction in area***.

$$\%EL = \left[\frac{L_f - L_0}{L_0}\right] * 100$$

$$\%RA = \left[\frac{A_0 - A_f}{A_0}\right] * 100$$



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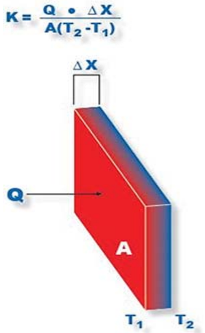
Thermal Properties

- **Thermal Conductivity:**

is the property of a material to conduct heat. It is evaluated primarily in terms of the Fourier's Law for heat conduction.

$$Q = -kA\frac{dT}{dx}$$

Rearrange ⇒ $k = -\frac{Q\,\Delta x}{A\,\Delta T} \quad (\frac{W}{m\,K})$



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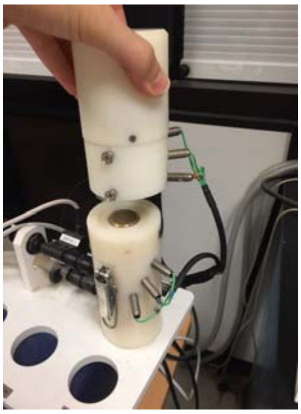
Procedure for Testing Samples

1 - Turn on the cooling water. adjust the flow.

2 - Set the heater voltage.

3 – Wait for 20 minutes.

4 - Record measurements.



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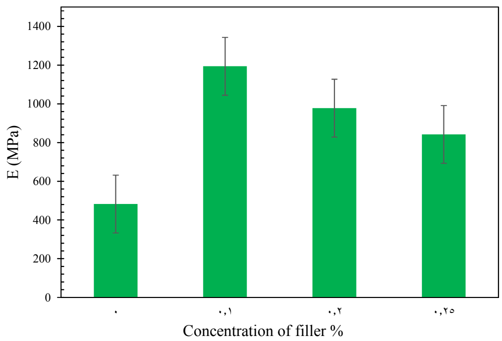
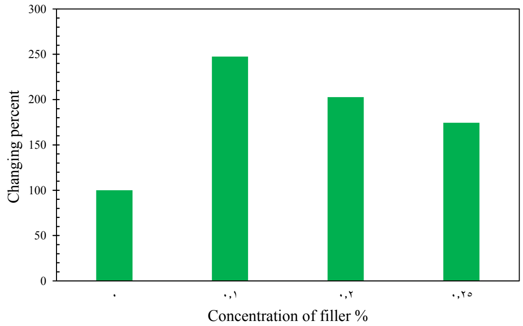
Without Vacuum

- **Modulus of Elasticity**





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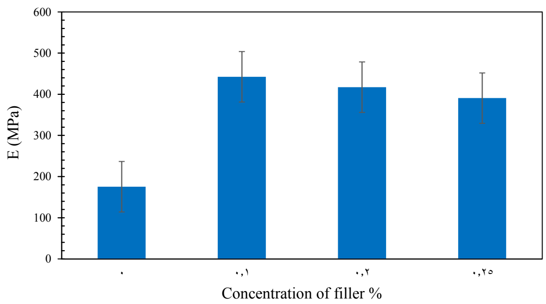
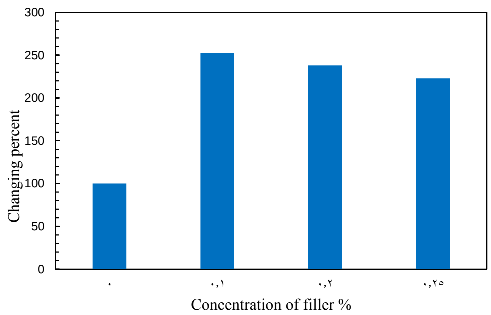
Under Vacuum

- **Modulus of Elasticity**





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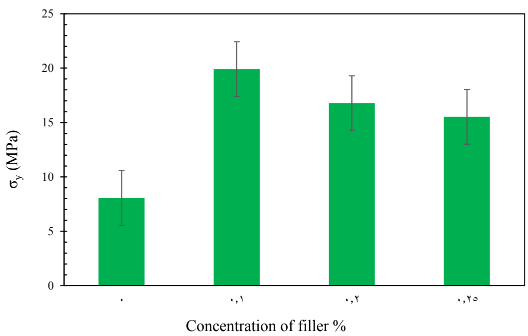
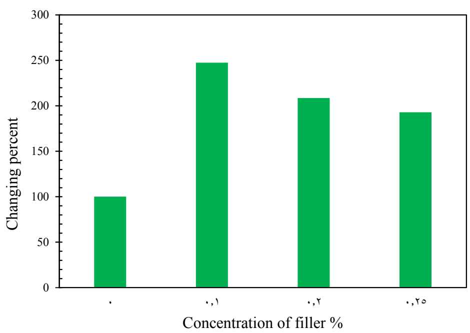
Without Vacuum

- **Yield Strength**





Under Vacuum

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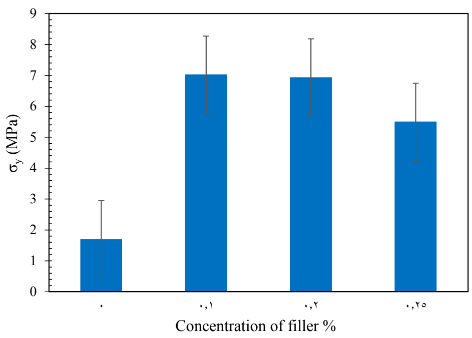
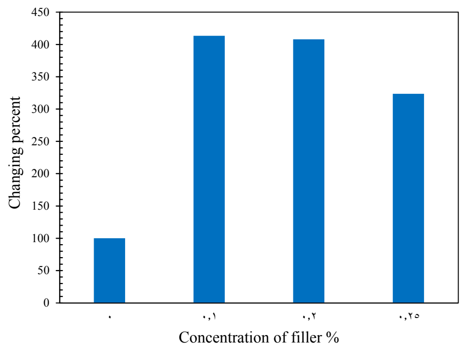
- **Yield strength**





Without Vacuum

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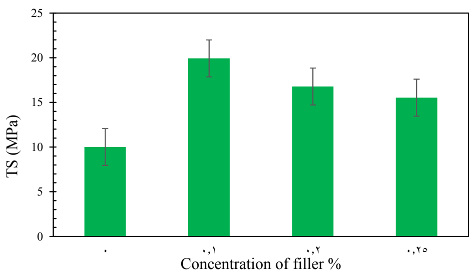
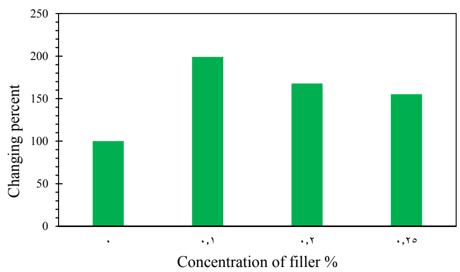
- **Tensile strength**





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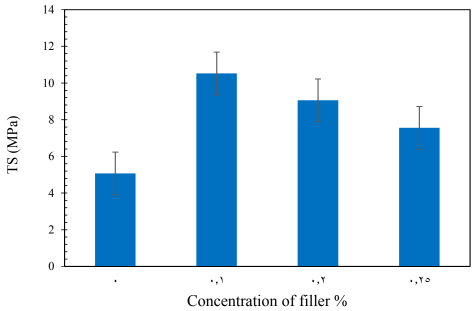
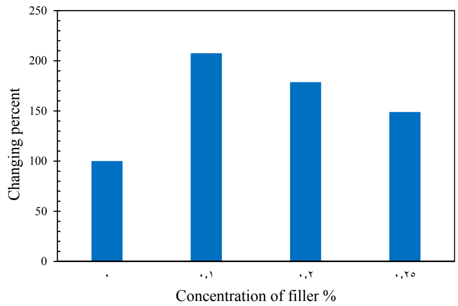
Under Vacuum

▶ **Tensile strength**





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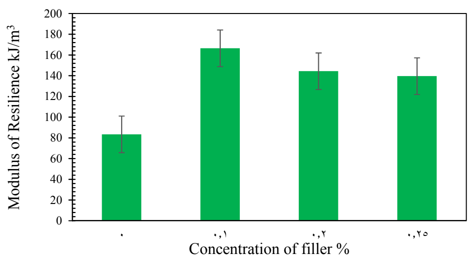
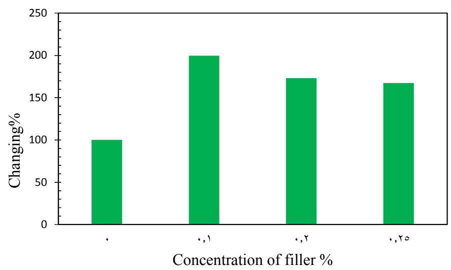
Without Vacuum

▶ **Modulus of Resilience:**





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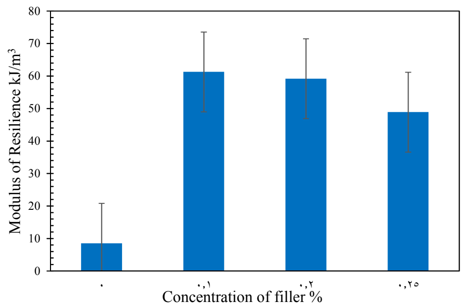
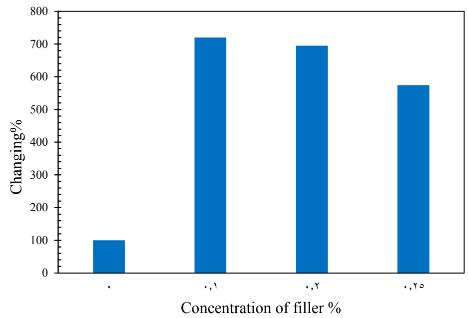
Under Vacuum

- **Modulus of Resilience:**





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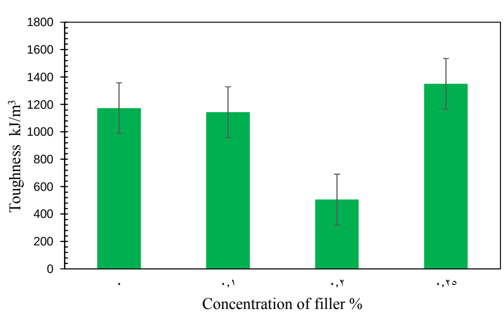
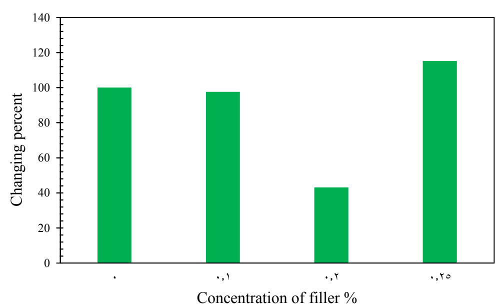
Without Vacuum

- **Toughness:**





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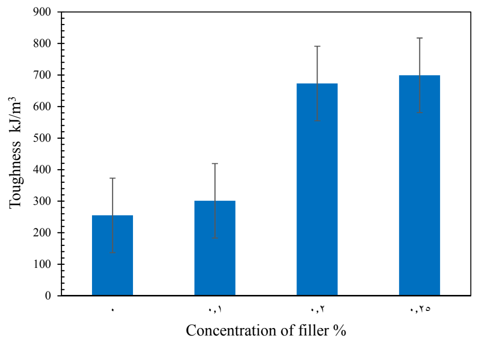
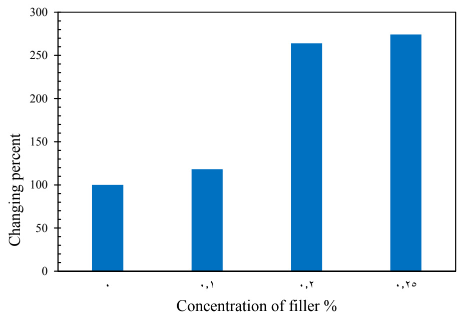
Under Vacuum

- **Toughness:**





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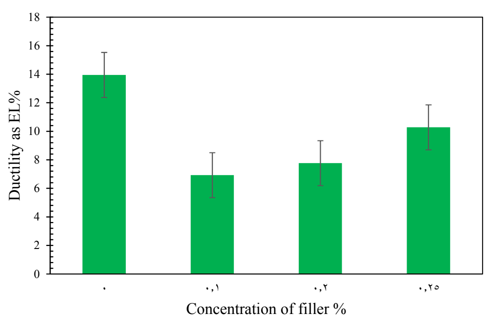
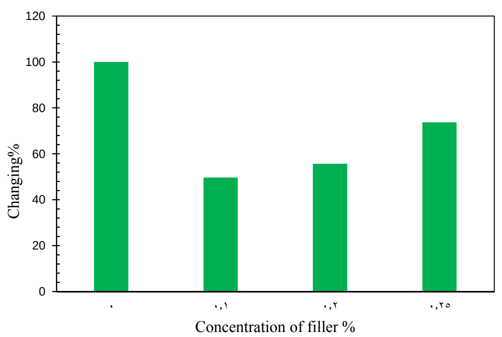
Without Vacuum

- **Ductility:**





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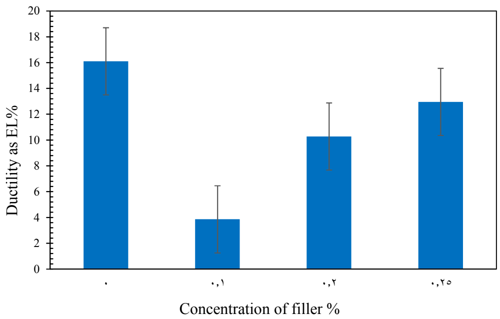
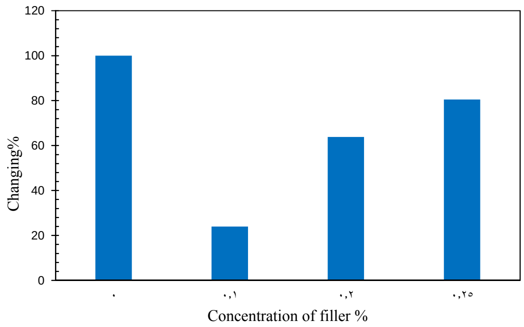
Under Vacuum

- **Ductility:**





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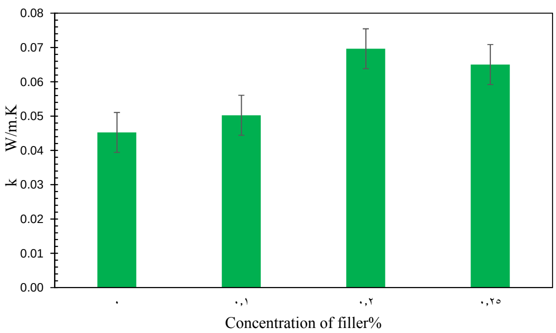
Thermal Properties
2.1 Thermal Conductivity

- **A. Without Vacuum**



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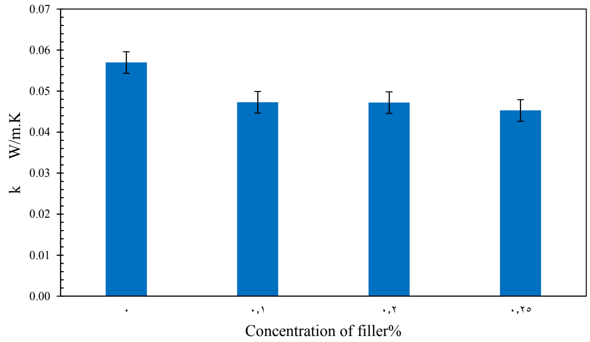
Thermal Properties
2.1 Thermal Conductivity

- **B. Under vacuum**



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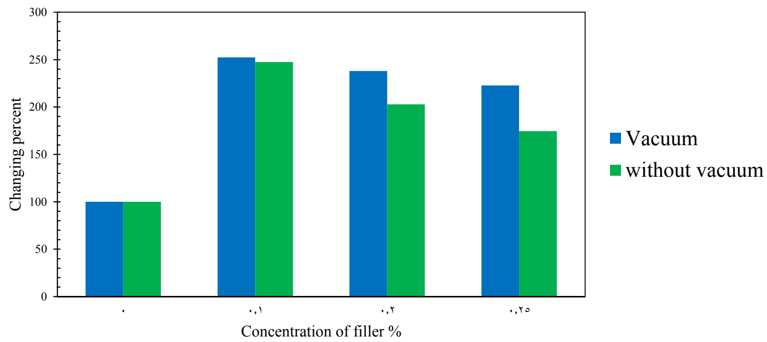
Comparison Between both approaches

- **Modulus of Elasticity**



Comparison Between both approaches

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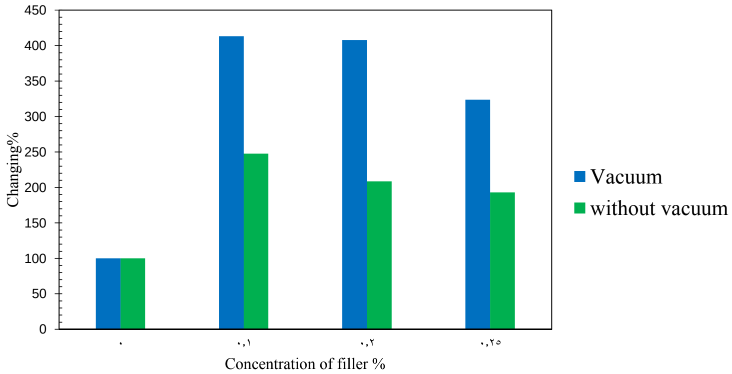
- **Yield Strength**



Comparison Between both approaches

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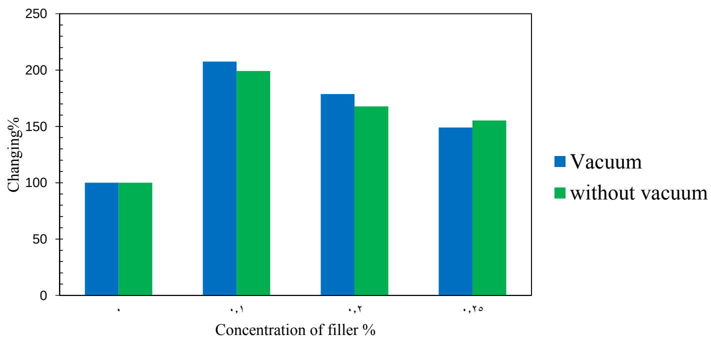
- **Tensile Strength**



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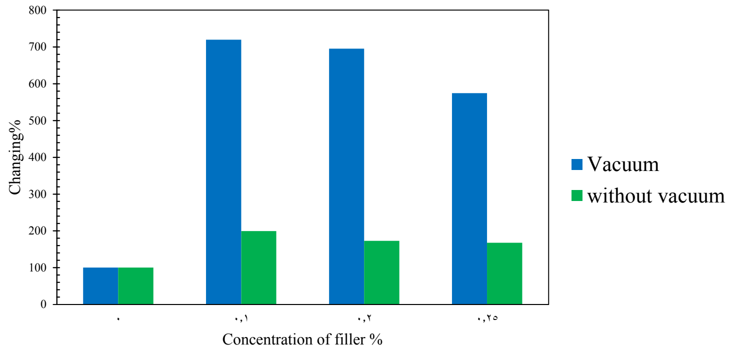
Comparison Between both approaches

- **Modulus of Resilience:**



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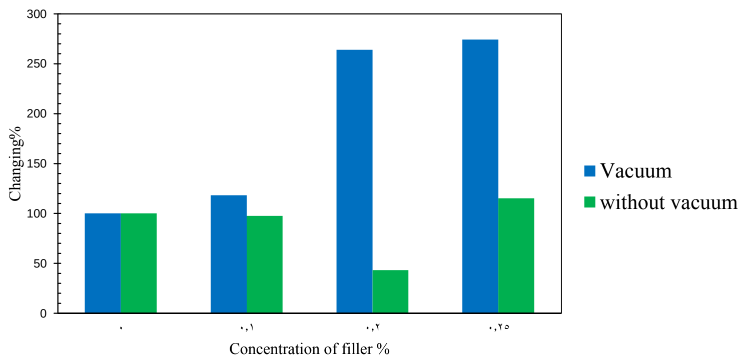
Comparison Between both approaches

- **Toughness:**



Comparison Between both approaches

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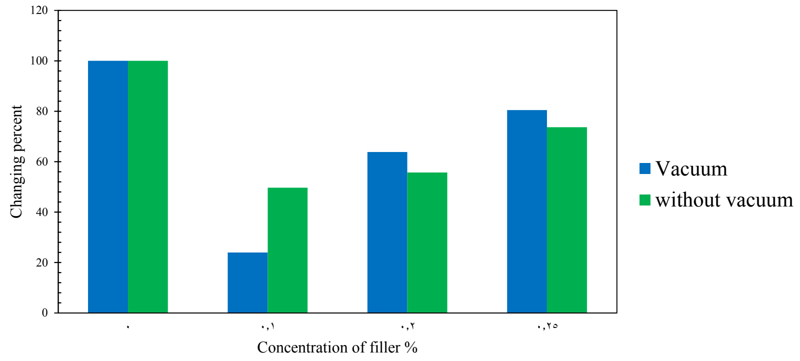
- **Ductility:**



Comparison Between both approaches

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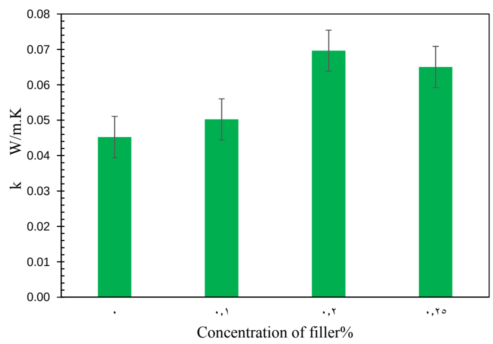
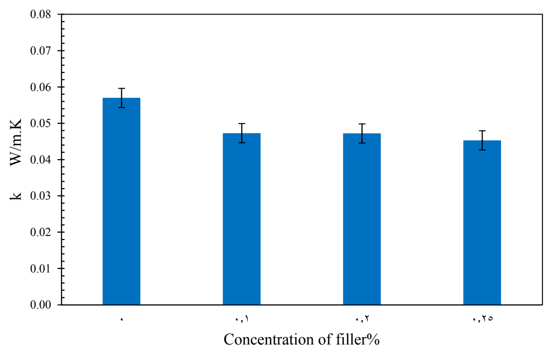
- **Thermal conductivity**

Without Vacuum



Under Vacuum



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Conclusion:

- For modulus of elasticity, tensile strength, yield strength and modulus of resilience. At **low concentration of DPLF**, great **increases** in these properties were obtained with the addition of small content of DPLF nanofibers.

- Further increasing in the concentration of DPLF will cause these mechanical properties to decrease.

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Conclusion:

- For the ductility, since the polymer has the highest ductility between the materials, adding DPLF will cause the ductility to decrease.

- The toughness was measured and its values slightly different at the different concentration of DPLF and **can be consider as a constant**.

- The thermal conductivity of this nanocomposite was measured and shows **constant** values at different concentrations of DPLF.

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Future Recommendations:

- We suggest to decrease the concentration of DPLF to less than 0.1 wt.% in order to get the better mechanical properties.
- We recommend to decrease the **processing temperature** as much as possible.

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Thank you
for Listening…