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Different Mechanical Properties between Two Types of PTFE Subjected to Heat Treatment

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ABSTRACT: In this research two kinds of pure polytetrafluoroethylene (PTFE) (C_2F_4). China_UAE source prepared from solution cast as film and strip have been studied by mechanical properties (Tensile testing instrument**)** subjected to different temperature heating cycle. Both modifications show variation inelongation at yield, stress at yield, elongation at break, stress at break, and young modulus) when temperature is changed. It seems that the product company of China is better than the product company of UAE in mechanical properties of this polymer.

KEYWORDS: PTFE, Mechanical properties.

I. INTRODUCTION

In this study, one of thermoplastic polymers was used; it is Polytetrafluoroethylene - (PTFE) (C_2F_4) n.
Polytetrafluoroethylene is a linear branchless extremely crystalline polymer with a melting point of (327 °C) and related to the family of fluoro plastics.
We have decided to restudy PTEF due to the lack of its mechanical data and its structural complexity. It is an exceptional material in many ways; it offers some beneficial properties over the widest temperature range in a better way than does any other polymer. It is resistant to almost all caustic and acidic materials and it is insoluble in all common solvents. PTFE has the highest resistivity of any material**,** low dielectric loss and a very high dielectric strength. Its availability from many manufacturers and its use as a common engineering material for small high performance parts. The sliding friction coefficient between PTFE and many of engineering materials is very low and when sintered with wear reducing compounds**,** an industrially remarkble class of bearing materials is produced [1,2].

The mechanical properties of polymer the characteristics exhibited by the material when subjected to externally applied mechanical force. In other term, mechanical properties speak about the reaction of a material to applied forces.
the most natural test of a material's mechanical properties is tensile test, in which a strip or cylinder of the material, having length L and cross-sectional area A, is anchored at one end and subjected to an axial load P – a load acting along the specimen's long axis – at the other.
The tensile test is popular since the properties obtained can be applied to design different components. The tensile test measures the resistance of a material to a static or slowly applied force. The strain rates in a tensile test are typically small [3,4].

In general, the stress as the force acting per unit area over which the force is applied. Strain is defined as the change in dimension per unit length. Stress is typically expressed in Pa (Pascals). Strain has no dimensions [5].
The stress over the circular cross section that is perpendicular to the axial load will be: $\mathbf{s}=\frac{\mathbf{F}}{\mathbf{A}}$…… (1)
Where *F is* the force applied and A is cross-sectional area
Strain = $\frac{\Delta L}{L}$…… (2)
Where L is the original length andΔL is the change in length [6].

Stress acquired at the highest applied force is called Tensile strength which is the maximum stress on the engineering stress strain curve. This amount is usually known as the ultimate tensile strength. At some point, one region is deformed more than others and a large, local decrease in the cross sectional area occurs. This locally deformed region is called the neck and this state is called necking. At this point a lower force is desired to continue its

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deformation due to smaller cross-sectional area, the engineering stress, determined from the original area A, decreases [7].

Young's modulus (*E*) or the modulus of elasticity is the slope of the stress strain curve in the elastic region. Hooke's Law is the relationship between stress and strain in the elastic region is known [8,9].

$$E = \frac{stress}{strain} \dots \quad (3)$$

II. EXPERIMENTAL

We used two sets samples of PTFE ribbon with different origins, the first set is a ribbon of polymer (PTFE) China origin and the second set is also a ribbon of (PTFE) but Emirates origin. By taking the bar is made of this article polymeric that prepared from solution cast as film and strip it has been preparing the two sets of samples in the form of a rectangular shape dimensions (14×1.9) cm.
The behavior of tensile samples was marked at room temperature by utilizing tensile testing instrument model (H50KT) produced by (Tinius
Olsen / UK). Samples were prepared as figure (1)

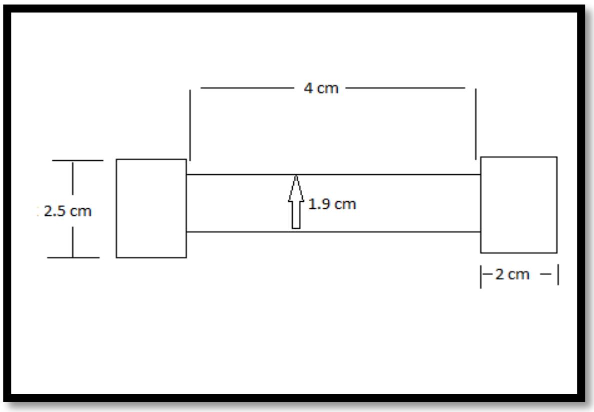

Figure (1)Planner for the dimensions of sample examination

The specimen was loaded at speed 5 mm/min between two grips adjusted by hand for (2000 N) computerized tensile test instrument, with an electronic expansion. Load-Elongation curves were recorded and yield stress and strain were calculated at the corresponding points to the Load-Elongation curve, we also calculate the amount of strain by identifying the difference between primary and final lengths occurring in process of drag when cutting the sampleand determine the Young modulus depending on the linear part of the stress-strain curve.
In this study, four samples of poly (tetrafluoroethylene) (PTFE) were tested at (RT, 100,200,250) $^{\circ}$Cto calculate the tensile properties of the samples.

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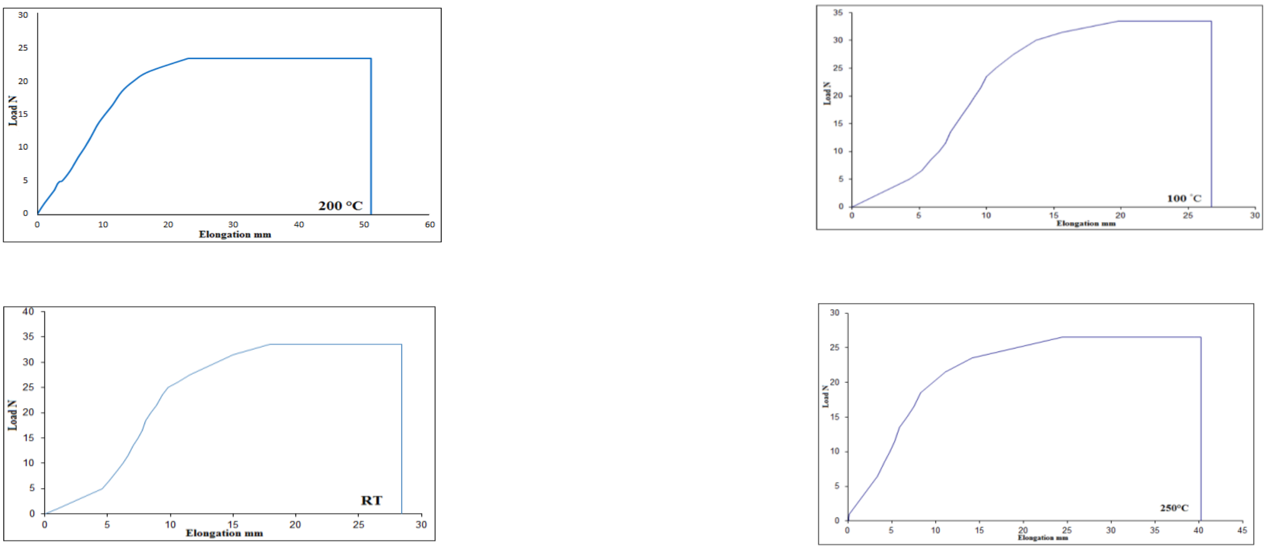
III. RESULTS

Load-Elongation curves for two types of PTFE samples are shown in figures (2a) and (2b) respectively.
From these tensile curves for PTFE, we can get young's modulus, stress at break, stress at yield, elongation at yield.



And elongation at break, which displayed in tables (1).

Fig. (2a) Load-Elongation curve for PTFE (type 1) with different temperature for polymer poly (tetrafluoroethylene) PTFE

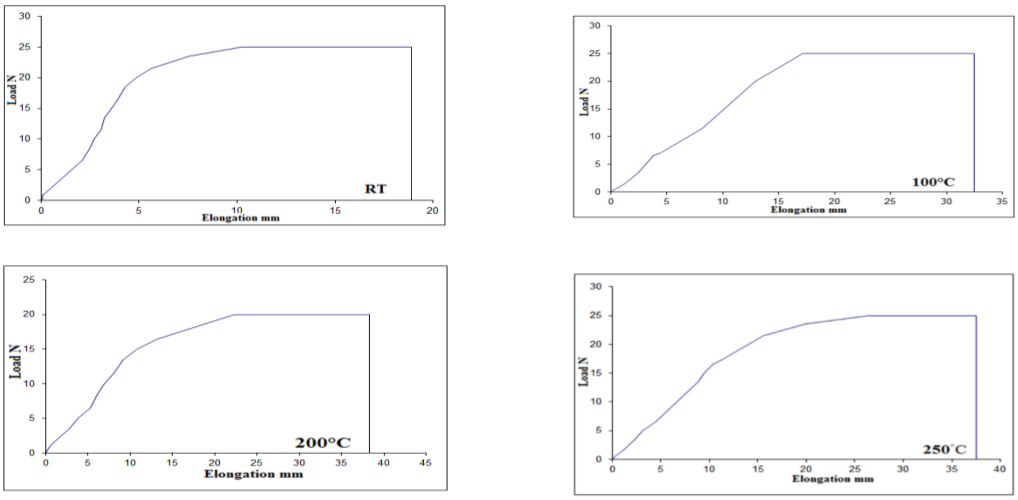


Fig. (2b) Load-Elongation curve for PTFE (type 2) with different temperature for polymer poly (tetrafluoroethylene) PTFE.

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By using equation (1) (2) and (3) we calculated stress, strain and Young modulus for PTFE samples for all temperature.

Table: (1) tensile properties of PTFE for two types

Type	T ($^{\circ}$C)	Y (Mpa)	σ_B (pa)	σ_y (pa)	ε_B (%)	ε_y (%)
(1)	RT	1.409	18190	16447	0.356	0.118
	100	1.142	22461	24896	0.421	0.21
	200	0.81	46735	29886	1.645	0.419
	250	1.094	47747	37837	2.056	0.5
(2)	RT	2.850	16447	13157	0.237	0.05
	100	2.203	20032	16025	0.515	0.203
	200	0.585	27159	22406	1.013	0.342
	250	0.827	41359	35566	1.209	0.5

From table (1) we can show the decrease in Young modulus with the increase of temperature because of the increase in stress with the increase in strain in type (1) slightly higher than type (2) because the strain in type (2) is less than type (1) this feature is applied for all semi-crystalline polymers.as in figure (3) below.

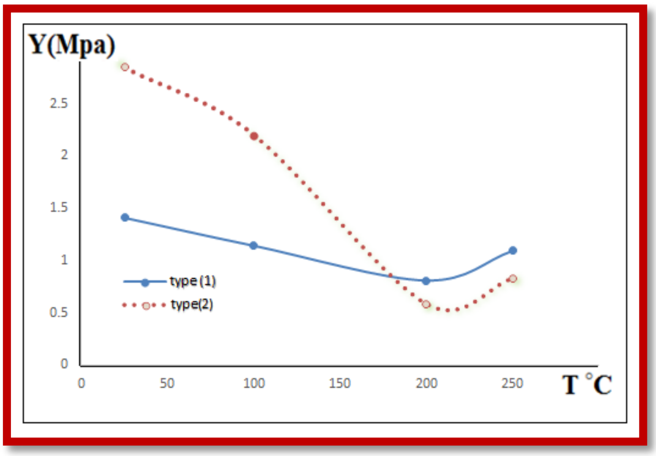

Figure (3) shows Young modulus as a function for heat treatment in different temperatures for two types of PTFE.

In another side the stress at break and stress at yield are increased with the increase of temperature and in type (1) which is higher than type (2) that is due to the increase of orientation of the molecular chains for polymer as in figure (4) and (5).

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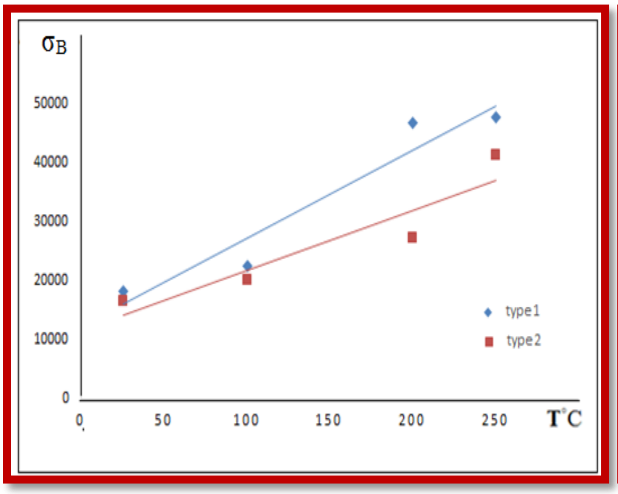


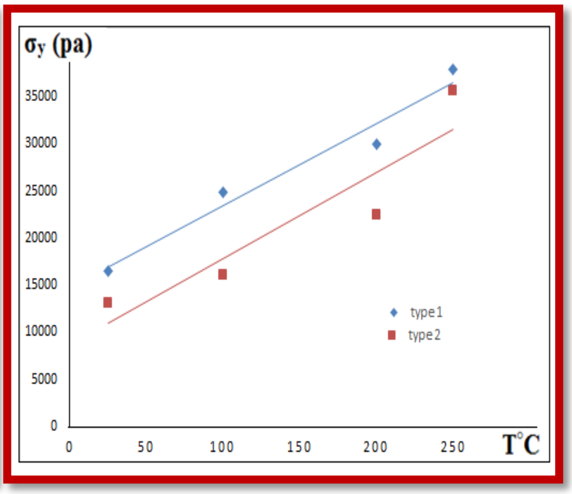
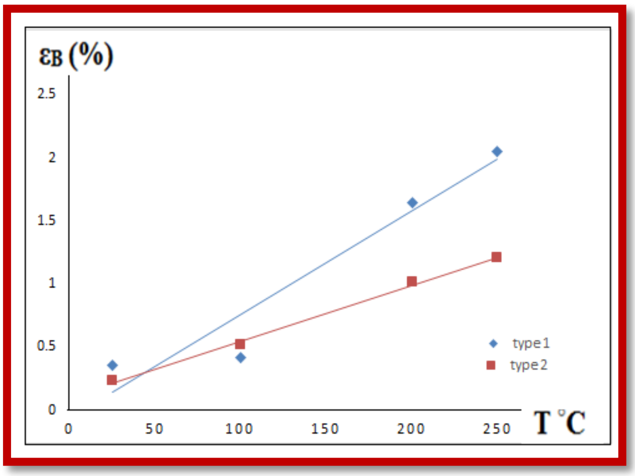


Figure (4) shows stress at break as a function for heat treatment in different temperatures PTFE.

Figure (5) shows stress at yield point as a function for heat heat treatment in different temperatures for two types of for two types of PTFE.



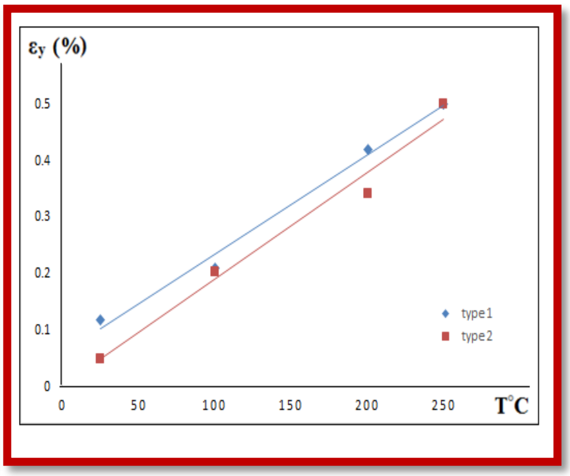


Figure (6) shows strain at breakdown as a function for heat treatment in different temperatures for two types of PTFE.

Figure (7) shows strain at yield point as a function for heat heat treatment in different for two types of PTFE. es

Figure (6) and (7) show the behavior of strain at break and at yield for two types increase with the increase of temperature and in type (1) which is higher than type (2) this is due to making the samples free to shrinkage during heat treatment. The increase in the strain attributed to the flexible behavior of the polymer, which explains the carried strain of hanging on both crystalline and random areaswith each other.

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IV . CONCLUSIONS

The heat treatment of polymer to different temperatures in order to know its properties and resistance to environmental conditions results showed that the mechanical properties increase linearly with the increase of temperature. The heat treatment led to improving the mechanical properties. Heating to (250°C) has led to the breaking of the bonds and formation of entanglement case which makes it the best and thus improving its properties for the appropriate environmental conditions.

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