

## Effect of Different Chemical Solution On Tensile Strength of Polymer Composite

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### Abstract

Hand lay- up technique was used to prepare sheets of epoxy composites reinforced with woven roven ( $0^{\circ}$ - $90^{\circ}$ ) glass fiber in weight fraction (50%). The sheets were left to solidify at room temperature ( $23 \pm 2^{\circ}\text{C}$ ). The samples immersed in (HCL, KOH, distilled water, Benzene, and Kerosene) for equal time at constant temperature ( $23 \pm 2^{\circ}\text{C}$ ). The tensile strength was calculated for the samples before and after immersion in different chemical solutions.

The result shown that the tensile strength of the samples decreased after immersion in different solutions, while (Kerosene) solution has maximum effect in decreasing the tensile strength of the sample, the (Benzene) solution has minimum effect in decreasing the tensile strength of the sample, and the other solutions (distilled water, HCL, KOH) located between them in different ratio.

Finally the samples immersed in (HCL) solution has maximum relative mass (minimum absorption resistance) while the sample immersed in distilled water has minimum relative mass (maximum absorption resistance).

### تأثير المحاليل الكيميائية المختلفة على مقاومة الشد للمركبات البوليمرية الخلاصة

استخدمت تقنية القولبة اليدوية لتحضير الواح من متراكبات الایبوكسي المدعمة بالالیاف الزجاجية النماذج في المحاليل الكيميائية (HCL, KOH, distilled water, Benzene, and Kerosene) لفترات زمنية متساوية في درجة حرارة الغرفة وتم حساب متانة الشد لكافة النماذج قبل وبعد الغمر في المحاليل الكيميائية. وظهرت النتائج ان متانة الشد تقل لكافة النماذج بعد غمرها بالمحاليل الكيميائية، حيث اظهر محلول الكيروسين اعلى تأثير لتقليل متانة الشد للنماذج بينما اظهر محلول المتعمدة الاتجاه ( $0^{\circ}$ - $90^{\circ}$ ) وبكسر وزني مقداره (50%). تركت الالواح لتتصلب في درجة حرارة الغرفة ( $23 \pm 2^{\circ}\text{C}$ ).

غمرت البنزين اقل تأثير على متانة الشد للنماذج وظهرت بقية المحاليل الكيميائية تأثيرا متباينا يقع بين المحلولين.

اخيرا تمتلك النماذج المغمورة في محلول (HCL) اعلى زيادة بالوزن بعد الغمر (الاوطى مقاومة للامتصاصية) بينما النماذج المغمورة في محلول الماء المقطر تمتلك اقل زيادة بالوزن بعد الغمر (الاعلى مقاومة للامتصاصية).

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## Introduction

Composite materials are defined as a materials consisting of two or more physically distinct phases, suitably arranged or distributed, the continues phase is referred to as the matrix, while the distributed phase is called the reinforcement, three things determine the characteristics of a composite: the matrix, the reinforcement and the interface between them [1, 2]. Woven fabrics composite have gained increasing technological importance. They provide more balanced properties in the fabric plane than unidirectional reinforcement in a single layer of fabric which gives rise to excellent mechanical properties the case of handling and low fabrication cost has made fabric attractive for structural applications [3]. One of the most common mechanical stress-strain test is performed in tension. The tension test can be used to a certain several mechanical properties of materials that are important in design. A specimen is deformed, usually to fracture the tensile testing machine to elongate the specimen at a constant rate, and to continuously and simultaneously measure the instantaneous applied load and the resulting elongations [4]. That load-minimize these geometrical factors load and elongation is normalized to the relation ship: [5].

$$\sigma = F/A \quad \dots\dots\dots (1)$$

In which F is the instantaneous load applied perpendicular to the specimen cross section, (A)

A: is the original cross sectional area before any load is applied.

$\sigma$ : tensile strength of the specimen (N/ mm<sup>2</sup>).

Diffusion is the process which matter is transfer from one part of the system to another as a result of random molecular motion of a single molecule that can be described in terms of the "random walk" picture. The solution penetration into polymer matrix composites involves three mechanisms:-

1. Diffusion of solution into the matrix directly and to a much lesser extend, in to the filler material.
2. Flow the solution molecules along the filler-matrix interface, followed by diffusion into the bulk matrix.
3. Transport of solution through micro cracks or other forms such as pores or small channels [6].

The aim of this work is to study the effect of different chemical solution on tensile strength in epoxy composites.

## Experimental work

1. Epoxy resin type (DGEBA) was used with its hardener in ratio (3:1).
2. The glass fibers used for reinforcing the epoxy resin was woven roven standard mat (E-glass) with surface density of (0.5 Kg/m<sup>2</sup>).
3. Hand lay-up technique was used to prepare sheets of epoxy composites reinforced with (0°-90°) glass fibers in weight fraction (50%).

4. The sheets were left to solidify at room temperature (23±2) °C for 24 hours.
5. Epoxy composites with standard dimensions (ANSI / ASTM D 638) for tensile strength test were prepared.

The tensile strength is calculated by applying the relation ship:

$$T_s = F / A$$

Where:

$T_s$ : Tensile strength (N/mm<sup>2</sup>)

F: Applied load on the sample.

A: Cross section area of the specimen.

Simple way used of study solutions effect and calculating diffusion coefficient of glass fibers reinforced epoxy composites consist of immersing an initially dry samples in different solutions at constant temperature for equal time and recording weight gain.

The solutions used in this work were HCL, KOH both with normality (0.5), distilled water, benzene, and kerosene.

The relative mass gain can be obtained by:

$$M\% = \frac{\text{mass wet} - \text{mass dry}}{\text{Mass of dry}} \times 100 \dots (2)$$

## Result and Discussion

Glass fibers reinforced resin composites have been well accepted as engineering materials for various applications as a common feature of composites, prominent, anisotropy in mechanical properties, which has high

fracture strength and stiffness along the fiber strengthening component [7].

Tensile resistance is considered a measure of the ability of a material to resist forces trying to pull and break it.

The polymeric materials are generally, strain characterized by their limited tensile but after they are strength with fibers they endure the largest part of strain imposed.

Deformation steps for composite materials can be summarized in the following steps:

First step: elasticity deformation of both fibers and matrix.

Second step: elasticity deformation of fibers and plastic deformation of the matrix.

Third step: plastic deformation of both fibers and the matrix.

Fourth step: breaking of fibers followed by a failure of the composite material [8]

### Swelling and dissolution:

When polymers are exposed to liquids the main forms of degradation are swelling and dissolution, with swelling; the liquid diffuses into and absorbed within the polymer.

The small solute molecules fit into and occupy positions among the polymer molecules. Thus the macromolecules are forced apart such that the specimen expands or swells therefore a wide variety of reactions and diverse consequences are possible for polymer degradation [9].

The results in table (1) and figure (1) shown that the tensile strength of all samples decreased after immersion in chemical solutions. The kerosene has maximum effect in reducing tensile strength due to the chemical composition of kerosene which

weakening the interface region between the epoxy and glass fibers making a separation between them as a result the tensile strength decreased[10].

In the other side the kerosene affected also on the epoxy (matrix), the covalent bonds ruptured due to heat energy, chemical reaction, increasing the degree of cross linking of epoxy chains, this process called (polymer degradation) as a result the tensile strength decreased[11]. While Benzene solution has minimum effect in reducing tensile strength because of the behavior of Benzene and its capability for self-association through intermolecular hydrogen-bonding with the interface region between epoxy and glass fibers[12].

From the results in table (2) and figure (2) the sample immersed in (HCL) solution has maximum relative mass (minimum absorption resistance) because that (HCL) is aggressive liquid, it reacts with epoxy, the ( $H^+$ ) ions making bonds with ends of epoxy chains producing  $H_2O$  molecules, while ( $CL^-$ ) ions weakening the interface region[13].

### Conclusions

1. Chemical solutions have major role in reducing the mechanical properties of the polymer composites in a process called chemical degradation.
2. The different chemical solutions have different effect on polymer composition, while the kerosene has maximum effect in changing the polymer chains, the benzene has minimum effect on polymer chains, and the other solutions

(HCL, KOH, distilled water) located between them.

3. The minimum absorption resistance (maximum mass gain) was for the samples immersed in (HCL) solution, while the maximum absorption resistance (minimum mass gain) was for the samples immersed in (distilled water).

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**Table (1) Tensile Strength of the Samples before and after immersion The tensile strength of the sample before immersion was 257.778 N/mm<sup>2</sup>**

<b>samples</b>	<b>Solution</b>	<b>F (N)</b>	<b>A(mm<sup>2</sup>)</b>	<b>T<sub>s</sub>=F/A (N/mm<sup>2</sup>)</b>
<b>1</b>	<b>Before immersion</b>	<b>10311.12</b>	<b>40</b>	<b>257.778</b>
<b>2</b>	<b>HCL</b>	<b>4742.52</b>	<b>40</b>	<b>118.563</b>
<b>3</b>	<b>KOH</b>	<b>3676.92</b>	<b>40</b>	<b>91.923</b>
<b>4</b>	<b>Distilled water</b>	<b>8189.37</b>	<b>40</b>	<b>204.734</b>
<b>5</b>	<b>Benzene</b>	<b>9881.03</b>	<b>40</b>	<b>247.025</b>
<b>6</b>	<b>Kerosene</b>	<b>1645</b>	<b>40</b>	<b>41.125</b>

**Table (2) Changing the relative mass gain of the samples with time after immersion**

<b>Time (day)</b>		<b>3</b>	<b>6</b>	<b>9</b>	<b>12</b>	<b>15</b>	<b>18</b>
<b>sample</b>	<b>solution</b>	<b>M<sub>1</sub> %</b>	<b>M<sub>2</sub> %</b>	<b>M<sub>3</sub> %</b>	<b>M<sub>4</sub> %</b>	<b>M<sub>5</sub> %</b>	<b>M<sub>6</sub> %</b>
<b>1</b>	<b>With out immersion</b>	—	—	—	—	—	—
<b>2</b>	<b>HCL</b>	<b>0.0299</b>	<b>0.0345</b>	<b>0.0397</b>	<b>0.0424</b>	<b>0.0457</b>	<b>0.0529</b>
<b>3</b>	<b>KOH</b>	<b>0.0073</b>	<b>0.0119</b>	<b>0.0124</b>	<b>0.0144</b>	<b>0.0168</b>	<b>0.0210</b>
<b>4</b>	<b>Distilled water</b>	<b>0.00092</b>	<b>0.0014</b>	<b>0.0039</b>	<b>0.0034</b>	<b>0.0042</b>	<b>0.0021</b>
<b>5</b>	<b>Benzene</b>	<b>0.0336</b>	<b>0.0353</b>	<b>0.0411</b>	<b>0.0482</b>	<b>0.0497</b>	<b>0.0497</b>
<b>6</b>	<b>Kerosene</b>	<b>0.0437</b>	<b>0.0427</b>	<b>0.0427</b>	<b>0.0447</b>	<b>0.0446</b>	<b>0.0429</b>

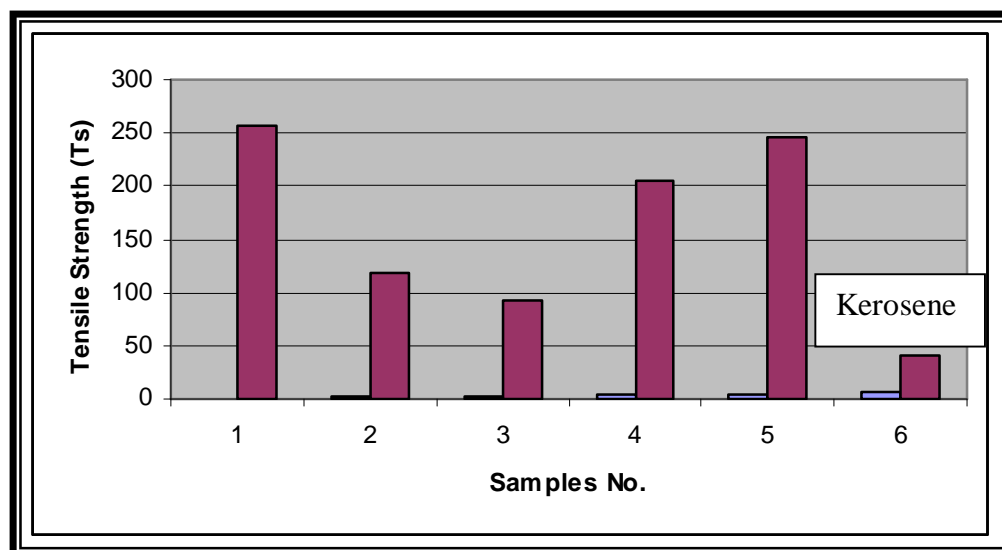


Figure (1) Tensile Strength of the Samples before and after immersion.

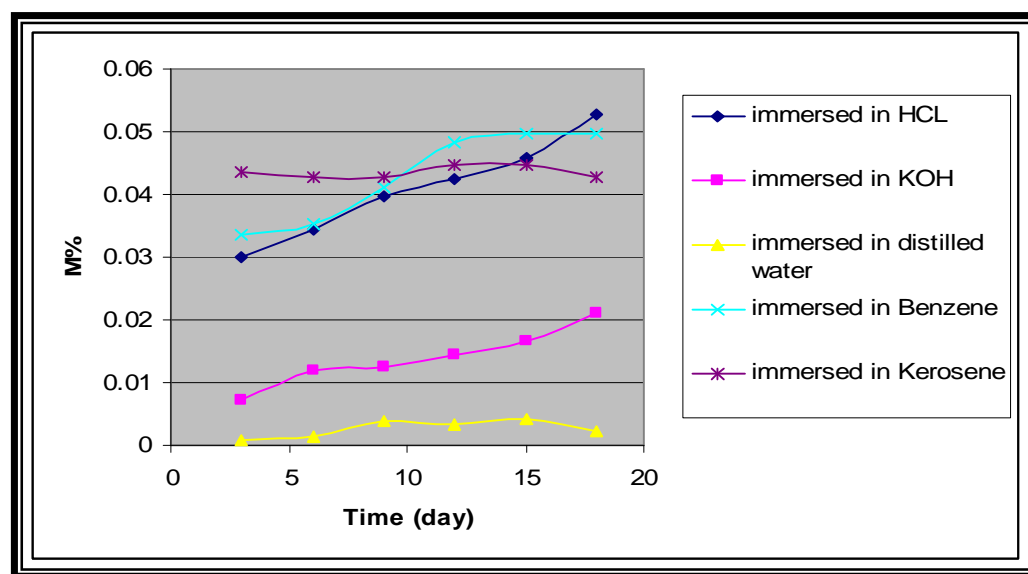


Figure (2) Changing the relative mass of the samples after immersion time.