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The Influence of Aggressive Media on the Weight and Surface Hardness of Epoxy-Glass Waste Composite

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Abstract

The world is evolving toward a circular economy, which focuses on decreasing waste and extending the life of commodities. This work suggests using waste of glass to prepare composite. Epoxy was reinforced 50% by weight using waste glass. At room temperature were prepared samples reinforced and unreinforced and immersed in five solutions (HCl, Water, NaOH, Kerosene and Benzene) for four weeks, to find out the resistance of the epoxy after reinforcing. It is found that reinforced samples have resistance of increased after immersion in corrosive media comparison pure epoxy and it was obvious that the hardness were modified by 57% and remain constant during the immersion period in solutions. After immersing specimens in HCl the weight of the specimens decreases by 3.6%, unlike other solutions the weight of the specimens' increase. Indicating that epoxy gains resistance after being reinforced with glass waste, allowing it to be used in a variety of applications.

1. Introduction

Proper waste management is one of the most important activities for resource conservation and environmental protection. In many countries, municipal solid waste management (MSWM) is a significant environmental concern. Rapid population growth, urbanization, and other factors have all contributed to the rapid growth of the population. The effects of industrialization and economic expansion, as well as changing lifestyles, have increased solidly creation of garbage. In emerging countries, the amount of solid waste had increased at a national level. Consistently rising over time [1].

Government departments, environmental authorities, regulators, and the general public are all concerned about how to manage such large amounts of urban solid trash. The growing volume of solid waste creates challenges for inefficient waste management (transport, storage, and disposal) [2]. Glass is a versatile material with many uses, and despite the fact that it is recyclable, waste glass is rarely used in its entirety [3]. Advantages of this technique, it low price, a simple process, environmental protection, and high energy efficiency, and they show great potential and broad prospects for application and reduce the amount of waste going into landfill sites (saving space), rate of raw materials consumed, pollution and litter. Considering the importance. At the same time, the proposed method provides a very effective way to comprehensively utilize waste glass and has remarkable economic and social benefits (Creates jobs and money for the people). In addition to Solid waste management serves to minimize greenhouse gas emissions, mostly methane and carbon dioxide, as well as the harmful effects of air pollution on public health [4, 5].

The development of lasting composite materials is the main task for most materials engineers. Ceramic particles filled polymer composites have piqued scientists' curiosity in recent decades, drawing scientific study that has revealed the polymer composite materials' substantial promise as a type of engineering material with better wear and friction qualities Polymer composites have become an important aspect of industrial applications due to their excellent tribologicsal, thermal, and mechanical properties. In addition to their inexpensive cost and easy-to-use capabilities. Polymer composites are a great choice for a unique form of engineering material. Epoxy is a thermosetting resin that is extensively utilized as a matrix in composite products. High performance thermosetting resins have been utilized for nearly half a century due to its unique qualities, which include high strength, low cost, the ability to be employed at temperatures up to 175 degrees Fahrenheit, and compatibility with most conventional reinforcements [6]. low cure shrinkage, lack of volatiles released during cure, strength, durability, adhesion, corrosion and chemical resistance, and other properties. Particulate fillers have been utilized to affect the mechanical and thermal properties of various matrices, according to various studies [7]. Due to these characteristics of epoxy composite materials are candidates to take the place of conventional metallic materials. In addition, although the strength of epoxies is high, it is not sufficient compared to metals. It has been shown in many studies that the addition of inorganic particulate fillers to the resin can increase the modulus, strength and many more properties of the epoxy resin[8]. It application in automotive, aerospace, electronic equipment, sport goods, furniture, medical equipment & packaging Industry. Composite materials used as an industrial material for their outstanding resistance to chemicals and most forms of corrosion [9] .

Polymers differ from ceramic and metallic materials in their propensity to absorb solutions and water; as a result, manufacturing containers for holding solutions in these materials might be problematic at times. Several investigations on polymers have been conducted, to reduce these problems such as, Tomáš et al[10]. The possibility of establishing the suitability of employing waste glass in polymer stabilizing materials was `investigated. The impact of a considerable volume of glass waste generated during the use, manufacture, and recycling of various types of glass on polymer properties, packaging glass materials have demonstrated to have the best properties. During the polymerization process, testing for tensile characteristics, pull test, thermal resistance, and temperature control are specified.

Anuja *et al* [7]. Found when compared to elegant epoxy resin, adding $CaSiO_3$ tiny particles at 1-2 percent by weight to pure epoxy improves mechanical qualities. The thermal behavior of reinforced and unreinforced epoxy was also investigated using thermogravimetric analysis (TGA) to determine the composites' thermal stability.

Erdoğan *et al* [11] . Used slag fillers (Al_2O_3, ferrochromium, blast furnace and converter powder) as a reinforcing material in epoxy composite of tribological applications. Samples were prepared with a constant 30% filler content. The melting furnace composites under all loading conditions showed maximum corrosion resistance.

Venkatesh et al[12]. Found this article the results of studies on epoxy mortars utilizing waste glass as a sand substitute in amounts ranging from 0% to 100% by weight. The flexural strength of the waste glass-containing mortars was found to be between 22,55 and 27,73 MPa, while the compressive strength was found to 68,67 MPa to 96,65 MPa, with absorbability of less than 0,73.

The purpose of this work is to provide the best possible insight into the use of industrial waste in the manufacture of composite materials as filler materials. To produce a new product with new modified properties at the lowest possible cost, for cleaning the environment of solid pollutants and the possibility of using them as an alternative material for various applications.

2. Experimental Procedure

2.1. Waste Water

Glass powder was obtained after crushing window glass by using an electric ceramic crusher and grinding in a specific ball mill for ceramic materials after sorting glass waste, separated forming bodies and cleaned to eliminate any impurities. A vibrator (sifting) / shaker was used to sieve the glass powder, yielding particle sizes of (0,212-0,075 m) as seen in the Figure (1).

Figure (1). Waste of glass powder.

2.2. Epoxy

Sikadur®-52, which may be ordered from SikaTM a low viscosity, shrinkage -free hardening, injection -liquid, epoxy resin with outstanding mechanical and adhesive strength was employed in the current work. Epoxy is a two-part liquid that includes resin and a hardener. When these two ingredients are mixed in a 2:1 ratio, they react over time to produce a solid cast after about 24 hours at room temperature. Epoxy resin was used as the composite's matrix material.

2.3. Specimen Preparation

According to the American Society for Testing and Materials Standard (ASTM), the manual technique (Hand lay-up) was utilized to construct the samples necessary for the research using a ready-to-cast mold composed of silicon. Pure and composite samples were prepared via mixing epoxy and glass particles in a weight proportion of (50%) and mixing them well for (7-10) minutes to achieve a homogeneous dispersion at room temperature. The fluid was then poured into the mold, causing it to flow consistently and continually. After 24 hours, samples were demolded. Each specimen is composed of epoxy that is both reinforced and unreinforced, the reinforced and unreinforced materials were cut into tiny cubed samples with dimensions of (1×1×1) cm and weighed weekly for one month using a sensitive electronic scale.

2.4. Preparation of Solutions

There were corrosive solutions (HCl, NaOH, Water, Kerosene and Benzene). The specimens were placed in glass containers containing the solutions, with the tops securely sealed to prevent evaporation, weights were recorded before and after immersion in these solutions. Water and chemical solution absorption by the composite material is influenced by the resin composition, crosslinking agent and chemistry, as well as the bonding and adhesion strength of the reinforcing phase to the resin used [13].

2.5. Weight Changes Test

The chemical resistance of a polymeric material is its ability to withstand chemical attack with minimal change in appearance, dimensions, mechanical properties and weight over a period of time.

2.6. Optical Microscope

This test was carried out utilizing an optical microscope (MEIJI/Japan) to examine the surface of the samples.

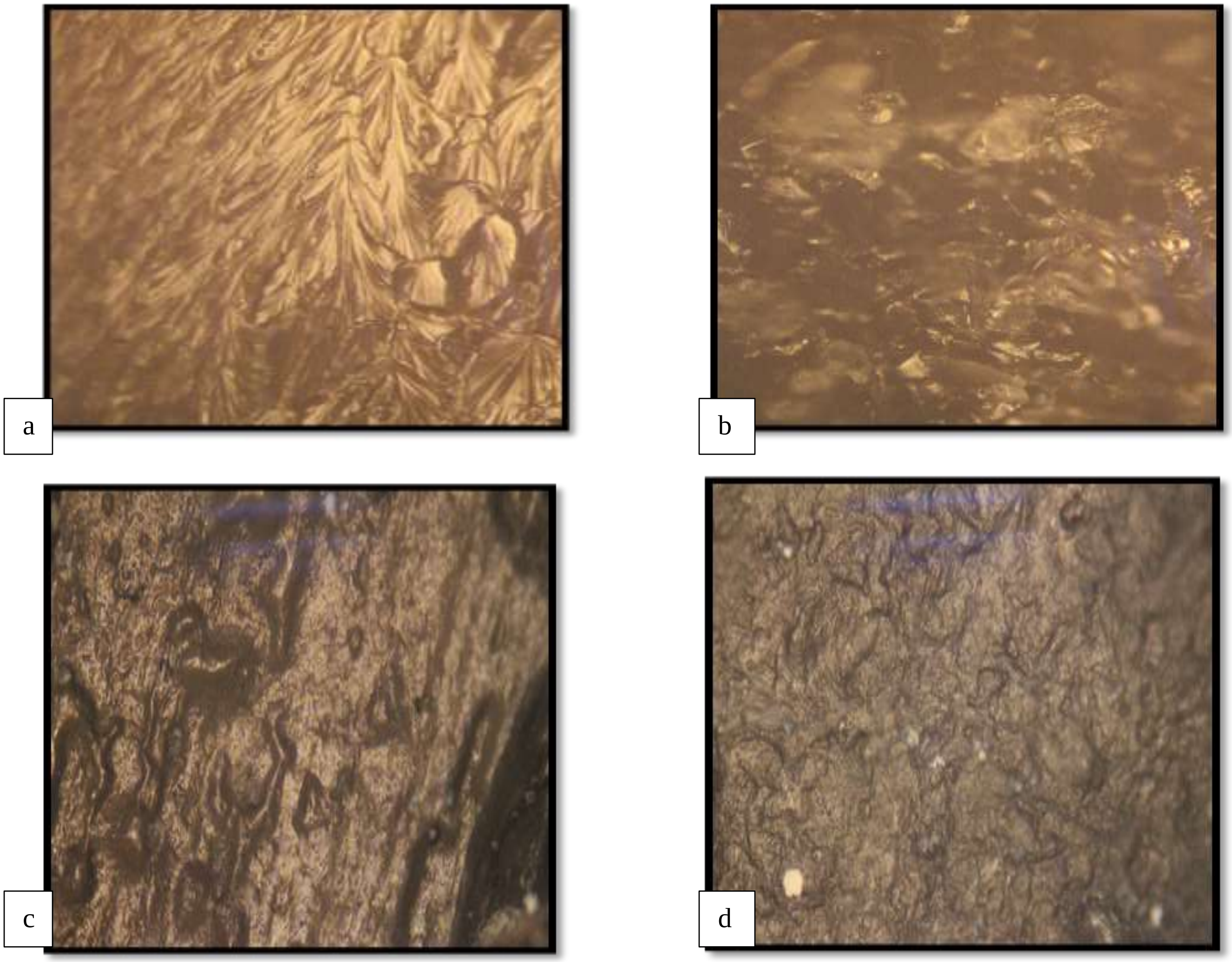
2.7. Hardness Test

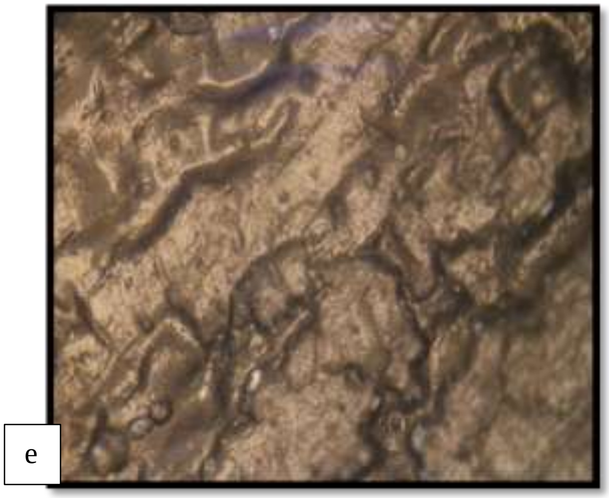
Surface resistance to abrasion and penetration from an applied force is a solid material attribute. Precision hardness tool made in China, model LARYEE HVS-1000, performs hardness resistance to international criteria (according to tool specifications). The specimens prepared according to ASTM (D-2240 standard).

3. Results and Discussion

3.1. Optical Microscope

Figure (2) shows micrographs of the prepared reinforced and unreinforced samples at room temperature before and after immersion. After immersion for one month there was no separation between the phases inside the composite materials. The bonding at the matrix-reinforcement interface was constant, it was not affected by any of the solutions, unlike unreinforced samples, all solutions were affected, and the most effective solutions was in (Water and HCl).





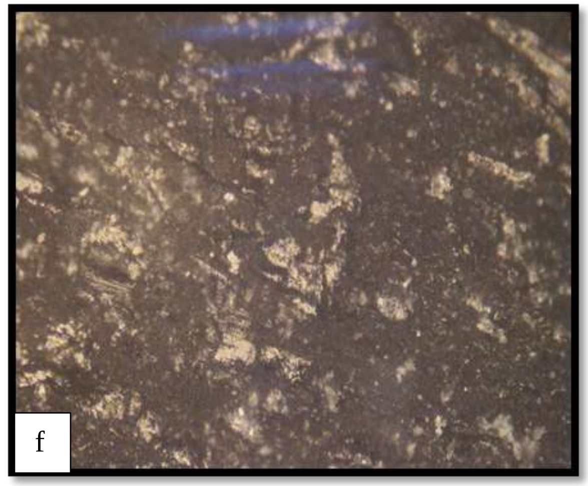


Figure (2). (a) Pure epoxy before immersion, (b) Composite before immersion, (c) Pure epoxy after immersion for one month into HCl (d) Composite after immersion for one month into HCl, (e) Pure epoxy after immersion for one month into water, (f) Composite after immersion for one month into Water.

3.2. Hardness Results

The material's hardness might be a good indicator of its overall mechanical performance. Surface resistance to abrasion and penetration from an applied force is a property of a solid substance [14]. Hardness behavior is showed in Table (1) after immersion for all sample surfaces, adding powdered glass waste to the epoxy improved the hardness of the surface layer significantly and that agree with Mohammed [6]. This Attribute to the glass remnants are high-hardness materials. Found that hardness increased by (57 %) for reinforced and remain constant during the immersion period in solutions at room temperature. Unlike epoxy pure, the hardness decreased by (14%, 13%, 9%, 4%, and 3%) in Water, HCl, NaOH, Kerosene and Benzene respectively, that clarified by microscopic images in Figure (2).

Table (1): Hardness of samples after the immersion in different solutions for one month.

Sample	Before	HCl	Water	NaOH	Benzene	Kerosene
pure R.T	11	9.55	9.36	9.96	10.48	10.81
composite R.T	17.28	17.2	17.22	17.25	17.27	17.3

3.3. Weight Changes results

Figures (3-6) shows the relationship between the change in weight with time for samples at room temperature immersed in (NaOH, water, kerosene and benzene). The weight of the unreinforced samples increases as the immersion period increases, due to the fact that when the polymer comes into touch with the liquid, it fills the spaces and gaps in the material quickly, breaking the chains and causing breakdown, unlike reinforcement, it remains stable. The higher change in weight was due to the diffusion of water molecules in the polymeric material, as most polymers do not dissolve in water, but rather absorb a certain percentage of it, and the properties of the polymer can be affected to a greater or lesser extent depending on the degree of absorption[13],[15]. This means that 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, which is agree with Emad [16].

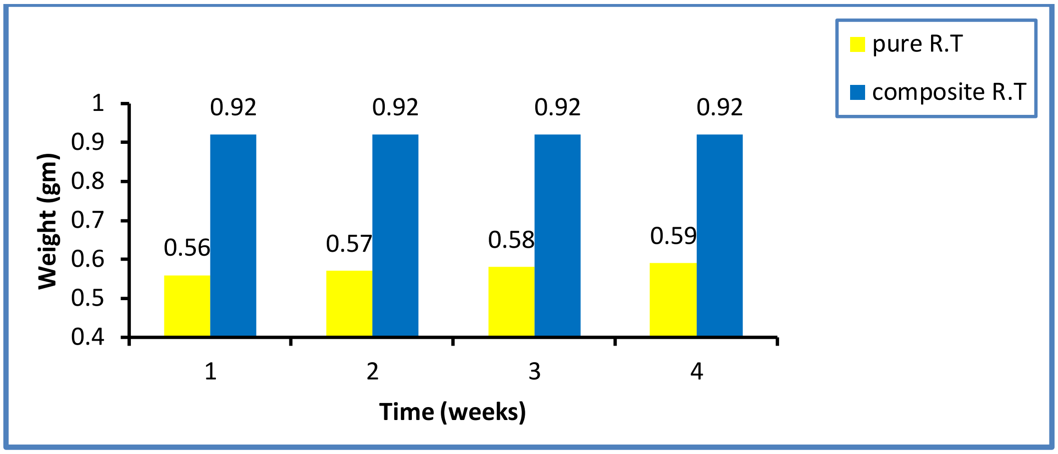


Figure (3). The relationship between weight change and time of samples immersed into NaOH.

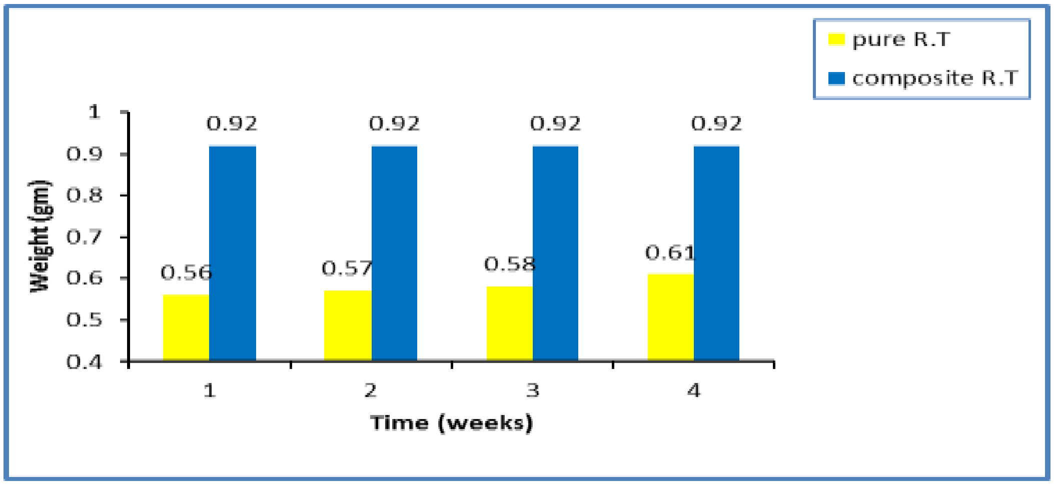


Figure (4). The relationship between weight change and time of samples immersed into water.

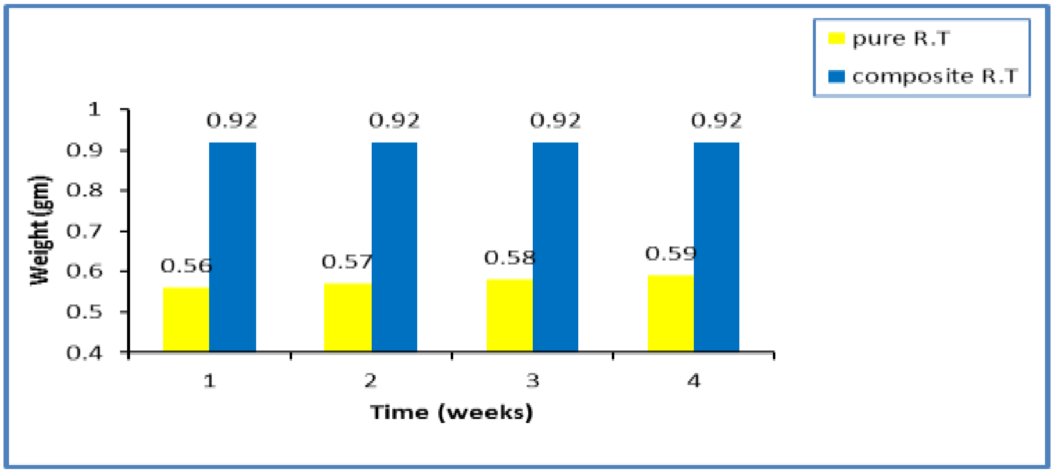


Figure (5). The relationship between weight change and time of samples immersed into kerosene.

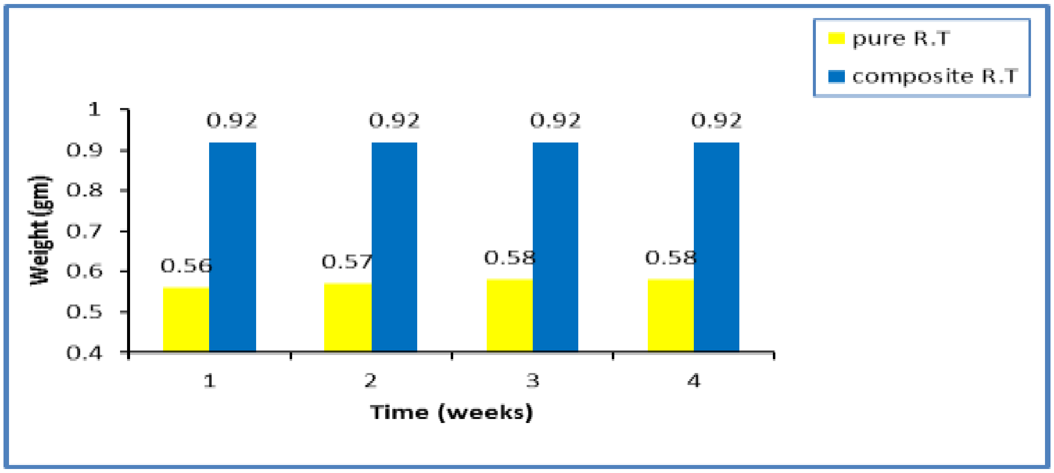


Figure (6). The relationship between weight change and time of samples immersed into benzene.

Figure (7) shows the relationship between the change in weight with time for samples at room temperature immersed in (HCl). The weight of the unreinforced samples decreases as the immersion period increases. The reason for this is that the decomposition of the polymer works to break down and decompose the interconnections, this decreasing in weight due to degradation in the epoxy chains by the effect of solutions this lead to forming interstitial holes that the solution molecules full it. Degradation operations associated with the decrease in the chemical resistance for the materials that lead to ability to loss compounds start from small polymeric chains happen associated with absorption operation but it slow and separated [17]. While reinforcement it remains stable.

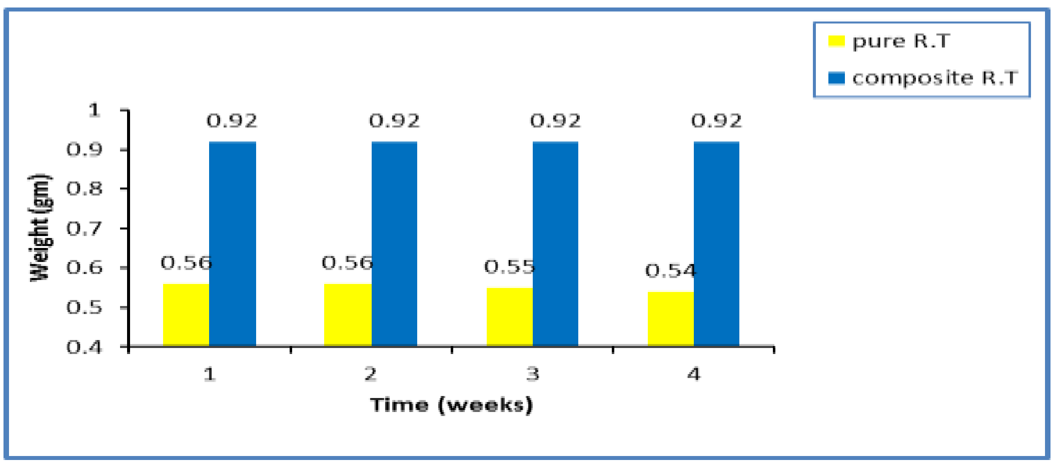


Figure (7). The relationship between weight change and time of samples immersed into HCl.

Figure (8) It is clear for the comparison between composites samples at room temperature, composites resistant to corrosive media were constant, due to the presence of glass which has a good high resistance to corrosion than other materials [18].

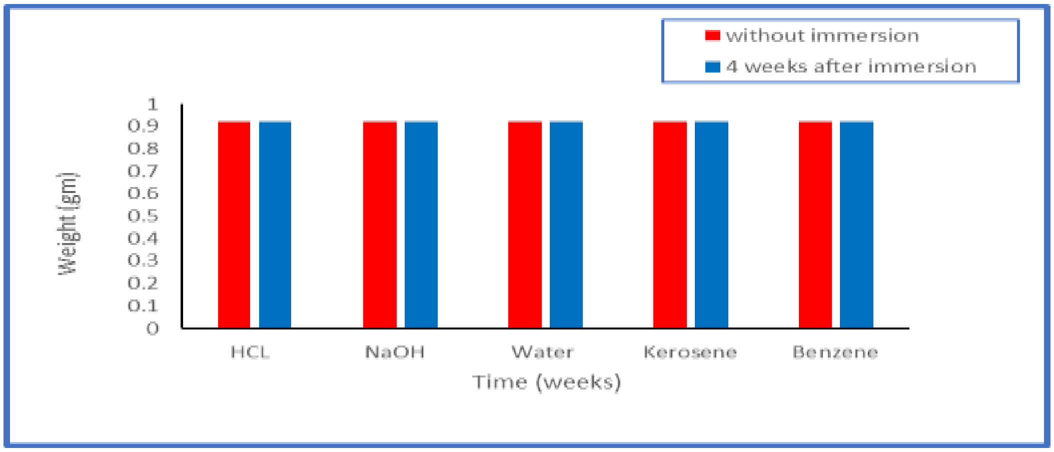


Figure (8). Comparison of Weight before and after immersion reinforced samples at room temperature.

4. Conclusions

This study found after four weeks that reinforced samples have resistance of increased after immersion in corrosive media unlike pure epoxy, because its weight does not change before and after immersion. The solution that has highest effect on the samples is (water) as it increases the weight unlike the (HCl) which leads to decrease weight samples decrease by (3.6%). Composites reinforced by glass particles show an increase in Hardness by (57%) and remain constant during the immersion period in solutions. This encourages glass waste recycling by producing composites with low cost and with high resistance to Aggressive media that may be used for a variety of applications.

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