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Chemical Resistance of Same Commercial Polymers

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Abstract

The aim of this work to study the effect of different liquids and chemical solutions on polymers. The polymers was choosing commercially is important (unplasticized PVC, plasticized PVC and polyester).

The results show the color change in samples after immersed in solution and in the same time show change in weight, the concentrated acid show more effect than anther solutions. The mechanical properties also affected by chemical solutions, the mechanical tests show decreasing in the flexure strength, compression strength and hardness values for glass-reinforced polyester, HNO_3 show more effective than anther chemical solutions, it is show decreasing in compression strength by 23% and in hardness by 22%, while the flexure strength reduced by 60%.

الخلاصة

الهدف من البحث الحالي دراسة تأثير سوائل ومحاليل كيميائية مختلفة على خواص البوليمرات، البوليمرات المختارة مهمـة تجاريا (البولي فينل كلورايد الغير ملدن و البولي فينل كلورايد الملدن والبولي استر).

أظهرت النتائج تغير في لون العينات بعد الغمر في المحاليل الكيميائية وبنفس الوقت اظهرة تغير في وزن العينات مع ملاحظة إن الحوامض المركزة أظهرت تأثير اكبر من بقية المحاليل. كذلك الخواص الميكانيكية تأثرت بالمحاليل الكيميائية فبينت الفحوصات الميكانيكية انخفاض في مقاومة الانثناء ومقاومة الانضغاط والصلادة للبولي استر المقوى بألياف الزجاج، اظهر حـامض HNO_3 تأثير اكبر من بقية المحاليل الكيميائية، إذ اظهر انخفاض في مقاومة الانضغاط بمقدار 23% وفي الصلادة بمقدار 22% بينمـا اظهر انخفاض في مقاومة الانثناء بمقدار 60% .

1.Introduction

The PVC and unsaturated polyester, which was choosing commercially is very important and widely used in applications now. More of this applications, which come with contact with different liquids, and chemical solutions, which caused corrosion and degradation of the polymer. This lead to different effects such as, deteriorates the materials which contacts with the polymer products, deteriorate the polymer itself and global pollutants (Mathew *et al,*. 2002).

There are several researchers investigated the effect of chemical solutions on polymer properties. Kevin (2003) studied the rheological properties of water-soluble polymers used in improved oil recovery. The corrosion resistance of polyvinyl chloride pipes immersed in tap water and different chemical solutions was investigated by Mahmoud *et al.* (2004). Padma *et al.* (2005) studied the chemical resistance properties to some acids, alkalies and solvents of waste silk fabric-reinforced epoxy laminates. The effect of NaOH treatment on the interfibrillar swelling and dyeing properties of lyocell fibers studied by Hale Bahar Öztürk *et al.* (2007).

-Poly (Vinyl Chloride) (PVC):

The PVC family consists of two contrasting types of materials, the rigid (unplasticized UPVC) plasticize PPVC see figure (1). Because of lower prices, widely

mechanical properties range and can be modified this properties by additives the PVC dominate the market (Sunny *et al* 2004).

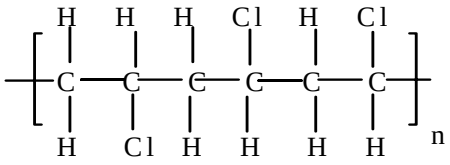

Figure (1): PVC structure.

- Glass –Reinforced Polyester (GRP):

Unsaturated polyester consists of unsaturated material maleic anhydride and ethylene glycol there are dissolved in a reactive monomer (styrene) see figure (2), when catalyst is added (Methyl Ethyl Ktone Peroxide MEKP) and accelerator (Cobalt Naphanate). The term GRP usually refers to glass – reinforced polyester, which are characterized by high stiffness, strength and toughness, resistance to chemical attack and dimensional stability. Major applications include building and construction, ship and boat hulls, chemical plant, and various forms of transport (Mathew *et al.*, 2002, Jan , 2005).

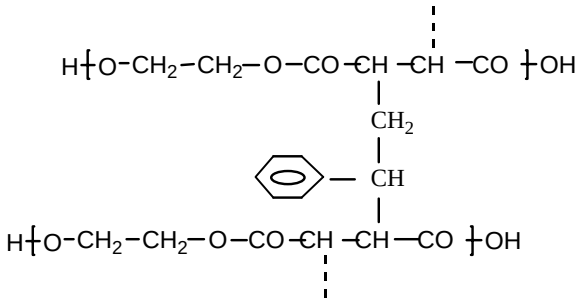

Figure (2): Unsaturated polyester structure.

2. Experimental Parts

- Materials Used:

Two different types of polymers were used in this work. The thermoplastic polymer (poly vinyl chloride PVC) was available locally in two types unplasticized PVC (UPVC) and plasticize PVC (PPVC). In addition, thermoset polymer (Unsaturated polyester UPE) reinforced with 40% volume fraction of glass fiber.

In this research select many chemical solutions usually came contiguities with polymers such as, tap water, sea water(10%NaCl), kerosene, lubricating oil, ethylalcohol, 40% sodium hydroxide,80% acetone and strong acids (conc.H_2SO_4, conc. HCl and conc. HNO_3 all acids 99% concentration).These selected solutions available locally.

- Chemical Attack Resistance:

The chemical resistance of the polymers was studied according to ASTM D543 method. Polymers specimens with different dimensions immersed in different liquids and chemical solutions for exposure periods of 14, 28, 42, 56 days. Changes in weight, color change and mechanical properties were measured.

- Water Absorption Test:

The same above samples dimension were dried in oven at 50 ^{o}C for 24 hours, cooled in a decicator and immediately weighed to the nearest 0.001g. In order to measure the water absorption of the polymers, all samples were immersed in water for about 24 h. at room temperature as described in ASTM D570-99 procedure. Excess water on the surface of the samples was removed before weighing. The percentage increase in weight during immersion was calculated as follows (Harper 2002).

Increase in weight %=[(Wet Wt. – Reconditioned Wt.) / Reconditioned Wt.]100

- Mechanical Test:

Flexural tests were performed according to the ASTM D790-86 with samples dimension (120x16x6)mm, dimension of compression test samples (10 Ø x 10) mm according to the ASTM 17581-88 , brinell hardness test was used according to the ASTM D785 with dimension (30 Ø x 6) mm . All tests above performed by PHYWE universal testing machine.

3- Results and Discussion

- Chemical Attack Resistance:

The percent weight loss/gain of the polymers after immersion in different chemicals solutions are presented in tables (1) to (3), and the color change after immersed in the same above solution are presented in figures (3) and (4). Which indicates that, there is a charge transfer complex formation result in this color change (Gertraund *et al.,* 2006).

Table (1) Weight loss / gain (%) of UPVC immersed in different chemicals solutions.

Chemical Solutions	Immersed time (day)			
	14	28	42	56
HCl (99%)	-0.267	-0.267	-0.375	-1.721
Acetone (80%)	-10.782	-12.793	-11.564	-3.016
Ethanol (100%)	0.163	0.109	0.163	-1.145
Kerosene (100%)	0.121	0.121	0.182	8.941
Lubricant (100%)	0.167	0	0.167	-8.314
Tap Water (100%)	0.165	0.055	0.22	1.047
NaOH (40%)	-0.114	-0.172	-0.057	-12.672
HNO_3 (99%)	0	-0.103	0	-3.630

Table (2) Weight loss / gain (%) of PPVC immersed in different chemicals solutions.

Chemical Solutions	Immersed time (day)			
	14	28	42	56
HCl (99%)	0.517	0.992	0.796	-9.713
Acetone (80%)	-30.363	-34.306	-30.060	2.956
Ethanol (100%)	-0.439	-2.436	-3.350	-17.292
Kerosene (100%)	-2.566	-4.448	-5.859	-6.458
Lubricant (100%)	0.180	-0.540	-1.036	-1.981
Tap Water (100%)	0.297	0.297	0.340	20.476
NaOH (40%)	0.073	-0.109	-0.439	-13.377
HNO_3 (99%)	0.988	-3.996	-5.274	4.367

Table (3) Weight loss / gain (%) of GRP immersed in different chemicals solutions.

Chemical Solutions	Immersed time (day)			
	14	28	42	56
HCl (99%)	-0.207	-0.228	-0.159	-0.021
Sea Water (10% NaCl)	-0.465	-0.583	-0.515	-0.480
NaOH (40%)	1.256	0.628	3.011	3.803
HNO_3 (99%)	0.987	2.069	4.481	4.653
H_2SO_4 (99%)	2.102	failure		

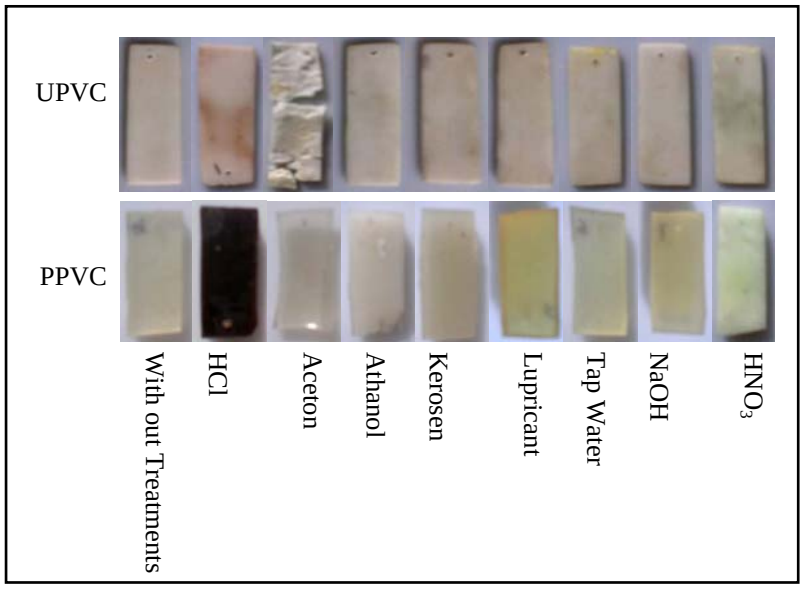

Figure (3) The effect of Chemical Attack Resistance on PVC color.

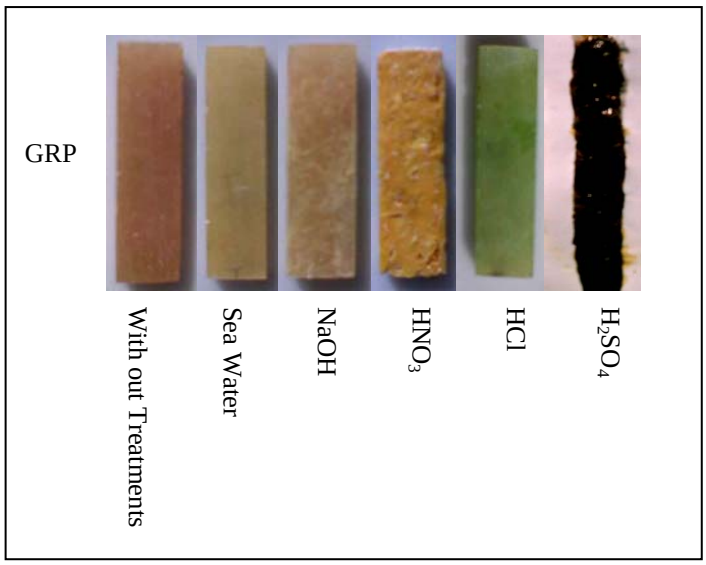

Figure (4) The effect of Chemical Attack Resistance on PVC color.

Figure (5) shows the effect of immersion time in acetone on weight of PPVC and UPVC sample. The weight loss in PPVC more than UPVC this due to high cohesive energy between UPVC chains while in PPVC the plasticizer materials increasing the distance between adjacent chains and reducing the effect of intermolecular forces so the solvent can break these forces easily (Boening 1973). With long time (above 42 day) the weight loss decreasing this duo to absorbing the acetone with increases the polymer degradation.

The relation between immersion time in concentration HCl and weight change of UPVC and PPVC shown in figure (6). This acid effect on PPVC more than UPVC this duo to existence the plasticizer in PPVC. The same behavior when immersed in kerosene (figure 7), ethanol (figure 8) and tap water (figure 9).

Figure (10) shows the effect of lubricant on UPVC and PPVC. The result shows no significant effect on polymer weight loss. The concentration H_2SO_4 show degradable behavior on UPVC and PPVC (see figure 11), NaOH show same behavior (figure 12).

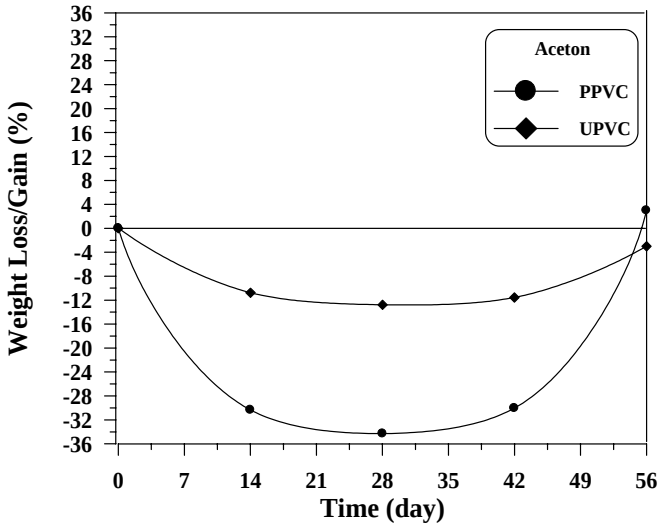

Figure (5) the effect of chemical solutions on weight change for PVC.

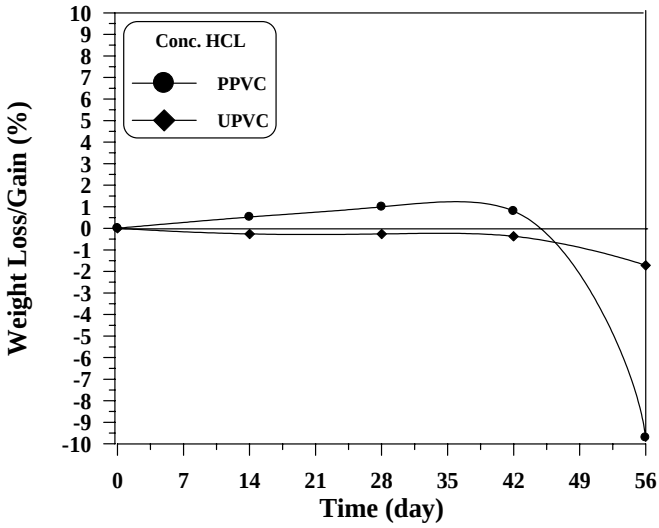

Figure (6) the effect of chemical solutions on weight change for PVC.

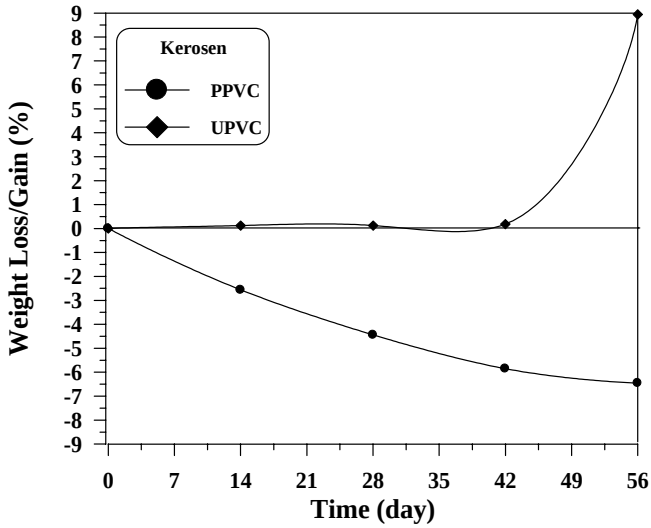

Figure (7) the effect of chemical solutions on weight change for PVC.

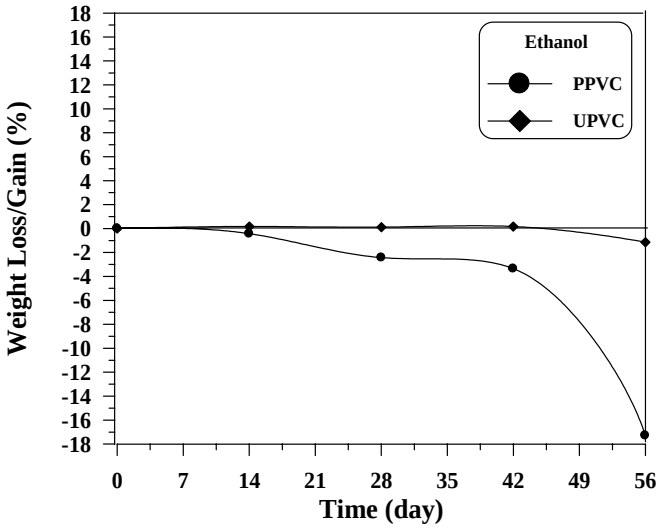

Figure (8) the effect of chemical solutions on weight change for PVC.

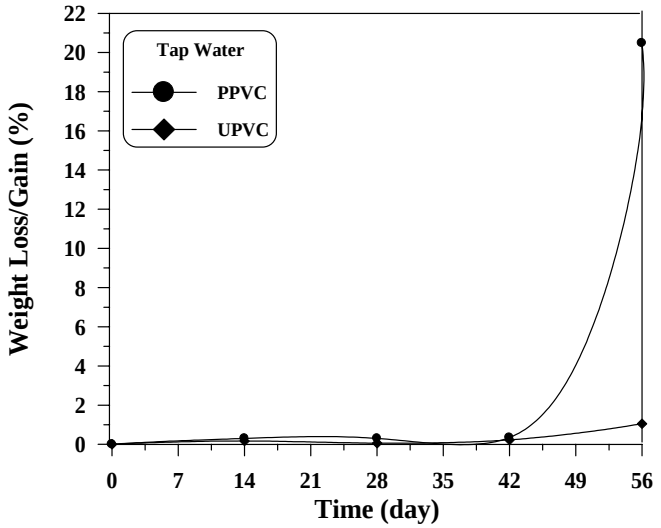

Figure (9) the effect of chemical solutions on weight change for PVC.

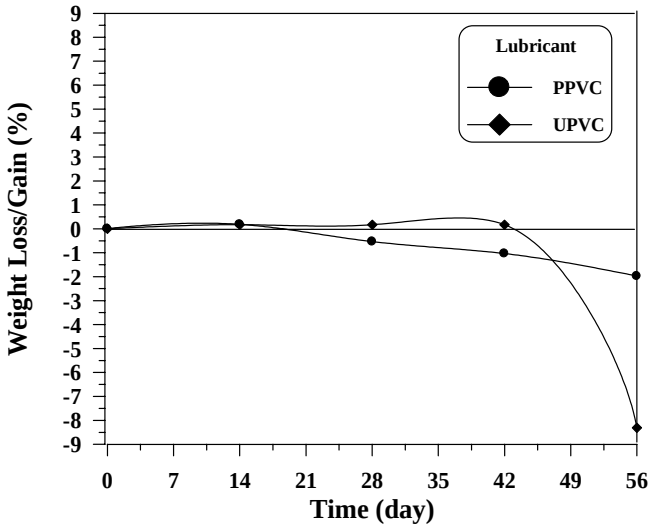

Figure (10) the effect of chemical solutions on weight change for PVC.

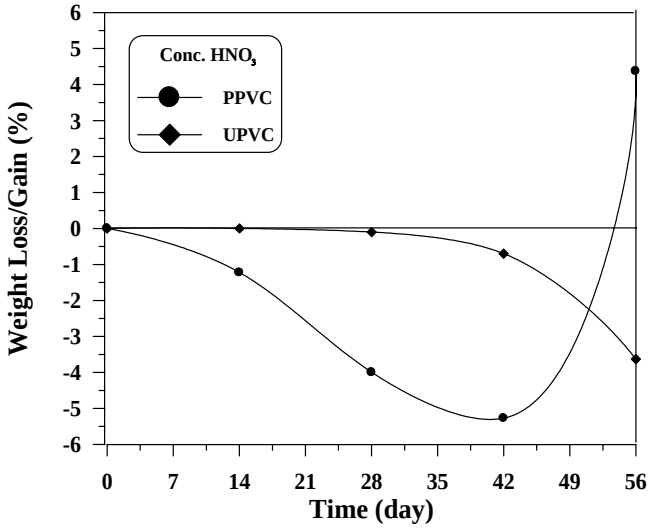

Figure (11) the effect of chemical solutions on weight change for PVC.

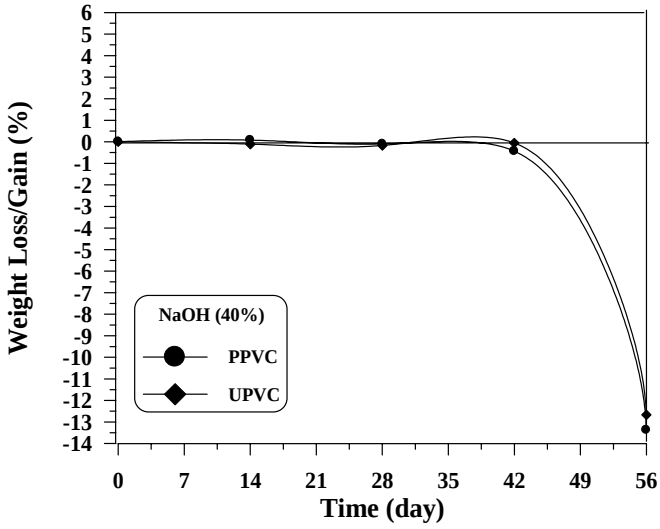

Figure (12) the effect of chemical solutions on weight change for PVC.

Figure (13) show the relation between times immersed in different chemical solution on weight loss/gain of GPR composite. The GPR show more resistance than two above polymers this due to cross-linking structure and reinforcement materials except the sample immersed in H_2SO_4 which failure after 28 days, another samples show weight gain with NaOH and HNO_3 this due to absorbed the solution, while the GPR samples immersed in sea water and HCl show weight loss this due to corrosion behavior.

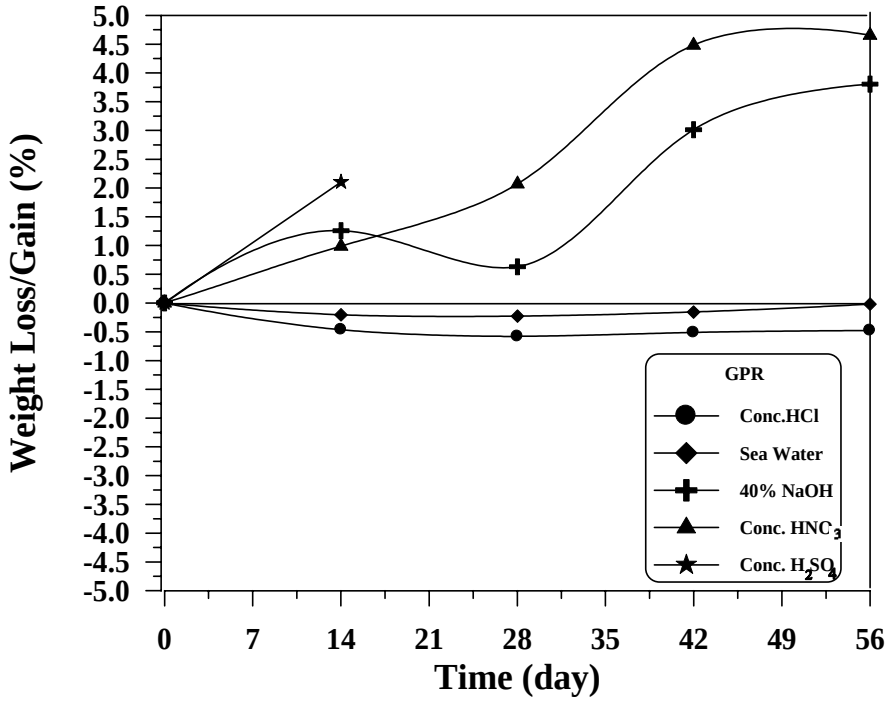

Figure (13) the effect of chemical solutions on weight change for GPR.

Figure (14) shows the effect of chemical solution on GPR composites. It is shown that all chemical are attack the composite material, mainly the matrix of the composite (i.e. the polyester).

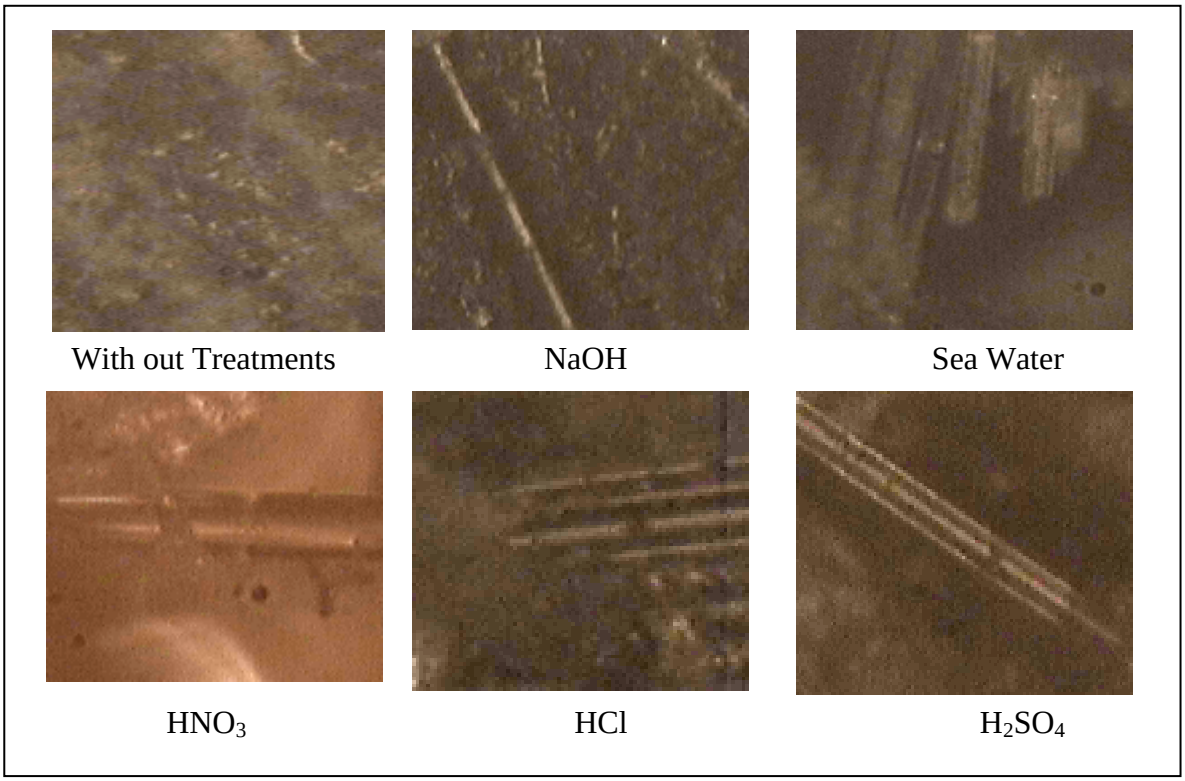

Figure (14) shows the micrographs of GPR composites after immersed in chemical solution.

- Water Absorption Test:

The percentage increase in weight is presented in figures (15), the GPR show low water absorption than UPVC and PPVC this due to high cross- link between the polyester chains.

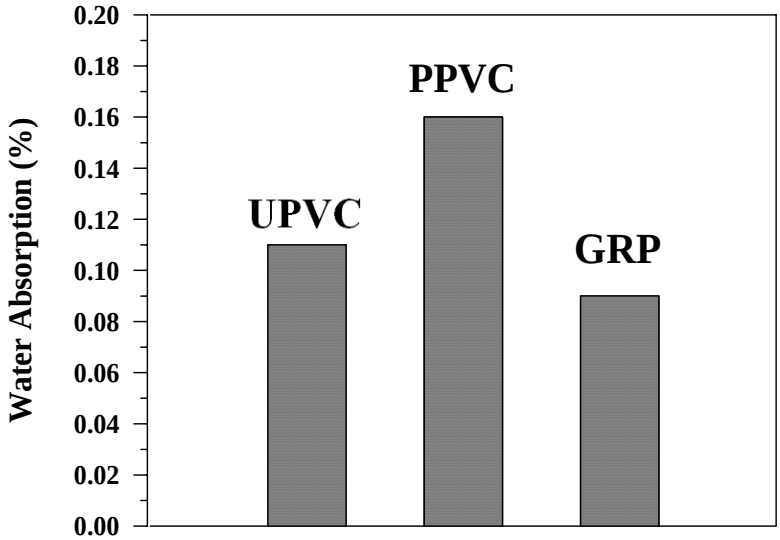

Figure (15) shows the Water Absorption percent.

- Mechanical Test:

Figure (16) show the effect of chemical solution on compression strength of GPR composite. The compression strength decreasing with increase immersion time this duo to degradation and absorption the solution this caused reducing in intermolecular forces.

The relation between chemical solution and brineel harness of GPR shown in figure (17) and effect of immersion time on flexure strength show in figure (18), the above result show decreasing in hardness values and flexure strength for the GPR this duo to deteriorating the polymer structure by the chemical solution. From above results show also the concentrated HNO_3 and HCl more effect on samples properties.

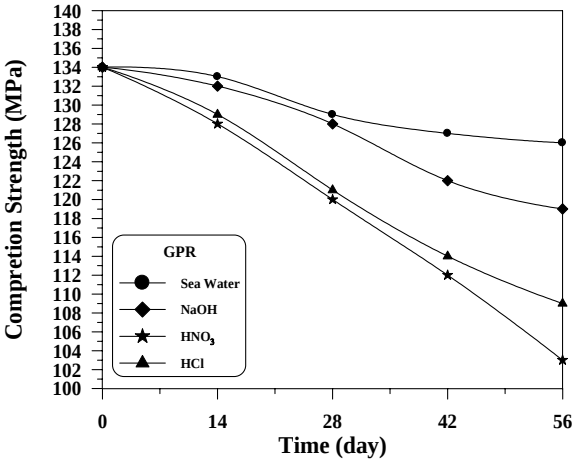

Figure (16) the effect of chemical solutions on compression strength for GPR.

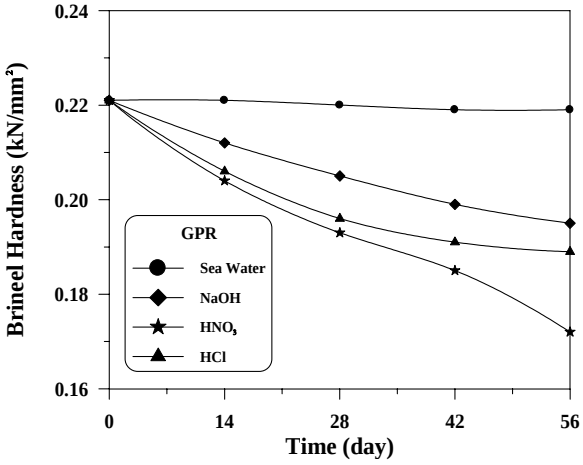

Figure (17) the effect of chemical solutions on hardness for GPR.

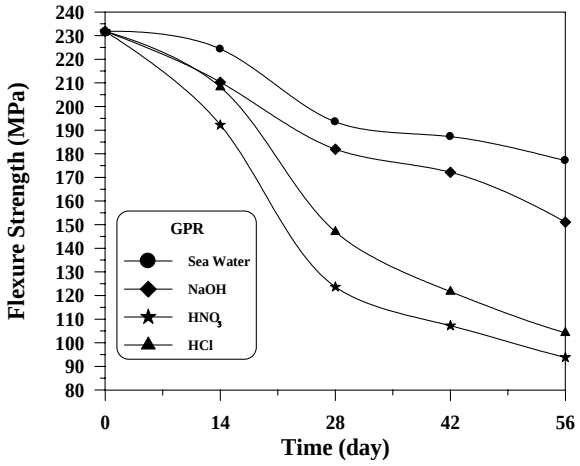

Figure (18) the effect of chemical solutions on flexure strength for GPR.

4- Conclusion

Immersed the polymers and composites samples in chemical solution show different behavior this according to polymer structure. The GPR show more resistance than UPVC and PPVC, this due to cross-linking structure besides existence the glass fibers as reinforcement materials except the sample immersed in H_2SO_4 which failure after 28 days. The PPVC have low resistance to chemical solution than UPVC. The chemical solution effect on mechanical properties, HNO_3 show more effect on these properties than HCl, NaOH and sea water. Table (4) shows the reducing in the mechanical properties percent when immersed in chemical solutions with different time.

Table (4) the change in the mechanical properties percent of GRP immersed in different chemicals solutions.

Mechanical Properties	Change in Mechanical Properties (%)			
	Sea	NaOH	HNO_3	HCl
Compression Strength	6	11	23	18
Hardness	1	12	22	14
Flexure Strength	23	78	60	55

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