THE EFFECT OF WATER ABSORPTION ON HARDNESS PROPERTY FOR EPOXY- PHENOL BLENDES REINFORCED WITH GLASS FIBERS[+]

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Abstract

(Epoxy – phenol) blend system was prepared and studied before and after reinforcing with glass fiber (woven roven O^o-90^o direction).
The samples immersed in distilled water for equal time at constant temperature (± 18 C^o).
The Brinell hardness of the system was measured before and after immersion in distilled water.
The results show that the Brinell hardness decreased after immersion in distilled water for blend samples with and without reinforcing with glass fibers. While the Brinell hardness increased after immersion in distilled water for epoxy samples with and without reinforcing with glass fibers. The diffusion coefficient was calculated for all samples after immersion, and it was obvious the sample (5) (Epoxy 80% - phenol 20% + glass fibers) has maximum diffusion coefficient (minimum absorption resistance) in comparing with other samples.

المستخلص :

تم في هذا البحث تحضير خلائط بوليمرية من الايبوكسي والفينول مدعمة بالالياف الزجاجية المتعامدة الاتجاه (^{o}٠-^{o}٩٠) وبدون التدعيم.

تم غمر النماذج في الماء المقطر لفترات زمنية متساوية وعند درجة حرارية ثابتة وهي درجة حرارة الغرفة ($\pm 18C^o$).

تم قياس خاصية الصلادة (صلادة برينل) لجميع النماذج قبل وبعد الغمر في الماء المقطر.

بينت النتائج ان صلادة برينل تقل للخلائط البوليميرية المدعمة والغير مدعمة بالالياف الزجاجية بعد الغمربالماء المقطر. في حين تزداد صلادة برينل لنماذج الايبوكسي المدعمة وغير المدعمة بالالياف الزجاجية بعد الغمر بالماء المقطر.

تم حساب معامل الانتشارلجميع النماذج بعد الغمر في الماء المقطر وتبين ان النموذج (٥) وهو(الايبوكسي ٨٠% +الفينول ٢٠% +الالياف الزجاجية) تمتلك اعلى معامل انتشارية (الاقل مقاومة للامتصاصية) مقارنة بالنماذج الاخرى.

Introduction

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Over the past few decades, 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 was observed, which has high fracture strength and stiffness along the fiber strengthening component [1].

Epoxy resins are one of the most popular materials used in industrial applications such as adhesives, coating, and especially composites depending on the chemical structures of the resins and the curing agent, and the availability of numerous modifying reactants epoxy resins can have a broad range of physical properties, mechanical capabilities and processing conditions that make them invaluable compared to other thermosetting resins [2, 3, 4].

Phenolic resins with low molecular weight can be used as curing agents for epoxy resins in high chemical resistance applications. Phenolic resin can react with epoxy resins via the reaction of the hydroxyl groups of the phenolic resin with the epoxide groups of the epoxy resins [5]. Research conducted on solution absorption by several workers. They indicated that water penetration into polymer matrix composites involves three mechanisms:

1. Diffusion of water molecules into the matrix directly and to a much lesser extend, in to the filler material.
2. flow the water molecules along the filler – matrix interface, followed by diffusion into the bulk matrix and
3. Transport of water through micro crakes or other forms of micro damage such as pores or small channels already present into material expanded by water [6, 7].

The aim of this work is studying the effect of distilled water on hardness property of polymer blends with and without reinforcing with glass fibers in comparing with polymer samples with and without reinforcing with glass fibers.

Experimental:

Hand lay-up molding is used for preparing composite materials with the following steps:

1. Prepare the mold.
2. Mixing the epoxy resin (Conbextra Ep10 Jorden Industry) with its hardener (Ep10) in ratio (3:1).
3. phynolic resin was dissolved in Alcohol and adding hexamathyle tetra amine (HMTA) as a hardener in ratio (14%) of the resin.

This mixture was placed in oven at ($50C^{o}$) to evaporate Alcohol.

4. The binary blend is obtained by adding epoxy polymer which is still in a liquid state to phenolic polymer by using mechanical mixer to form identical binary blend in different ratio as shown in table (1).
5. The blends are left for (96 hours) at room temperature then dried for (5hours) at ($50C^{o}$) to ensure completion of the process.
6. Glass fibers were added (woven roven 0^{o}-90^{o} direction) to the mixture in a complete way till obtaining a composite matching material cast in mold and left for (96 hours) to solidify and then placed in the oven at ($50C^{o}$).
7. The Brinell hardness measured for all the samples before and after immersion in distilled water.
8. The samples immersed in distilled water for equal time at constant temperature ($\pm 18C^{o}$) and recording the relative mass gain as shown in table (2).
9. The relative mass gain of the samples calculated by the law:

$$M\% = \frac{\text{mass of wet sample} - \text{mass of dry sample}}{\text{Mass of dry sample}} \times 100 \quad \ldots\ldots\ldots (1)$$

10. The diffusion coefficient and diffusion time was calculated for all samples as shown in table (3).

$$D = \pi \left(\frac{kb}{4M\infty}\right)^2 \quad \ldots\ldots\ldots\ldots (2)$$ Fick's second law [8]

Where:

D: diffusion coefficient

π : 3.14

b: thickness of the sample.

M∞: saturation moisture mass.

K: the slop of the curve between mass gain and immersion time.

$t_D = \pi\, b^2/16\, D$ …….. (3) [8]

Where

t_D: time of diffusion

Table (1): shows prepared samples and changing the Brinell hardness before and after immersion in distilled water.

symbol	samples prepared	before immersion HBr N/mm^2	after immersion HBr N/mm^2
1	Ep without addition	15.66	31.43
2	Ep + G.f	16.24	19.49
3	Ep 90%+ Re 10%	36.43	18.04
4	Ep 80%+ Re 20%	18.79	15.41
5	Ep 80% + Re 20% +G.f	19.49	15.66
6	Ep 70% +Re 30%	16.81	8.95
7	Ep 70% +Re 30% +G.f	46.41	29.06
8	Ep 60% +Re 40% +G.f	38.48	19.42

Where Ep: epoxy resin Re: phenolic resin G.f: glass fibers

Table (2): Changing the relative mass gain with increasing the immersion time.

Time (day)	0	12	24	36	48	60
sample	mo(gm)	m_1	m_2	m_3	m_4	m_5
1	5.6241	5.7258	5.7875	5.7477	5.7675	5.7781
2	3.7568	4.3113	4.3294	4.3025	4.3015	4.3433
3	5.5227	5.8863	5.8222	5.8224	5.9217	5.9327
4	5.5189	6.2746	6.4419	6.4437	6.5245	6.5889
5	3.6879	4.0196	4.0813	4.0645	4.0518	4.o354
6	5.1535	5.4473	5.4023	5.4561	5.5138	5.5232
7	3.5394	3.8015	3.9175	3.8683	3.7072	3.5881
8	3.7911	3.9584	3.9175	3.8993	3.8881	3.7989

Table (3): Changing the diffusion coefficient with diffusion time.

sample	b (mm)	K	D	tD (hr)
1	3.8	0.028	2.609	1073
2	2.5	0.033	0.53	2358
3	3.9	0.054	1.545	1962
4	4.4	0.108	1.185	3267
5	2.4	0.341	11.647	98
6	4	0.054	1.811	1766
7	2.3	0.254	5.491	192
8	2.5	0.066	2.758	453

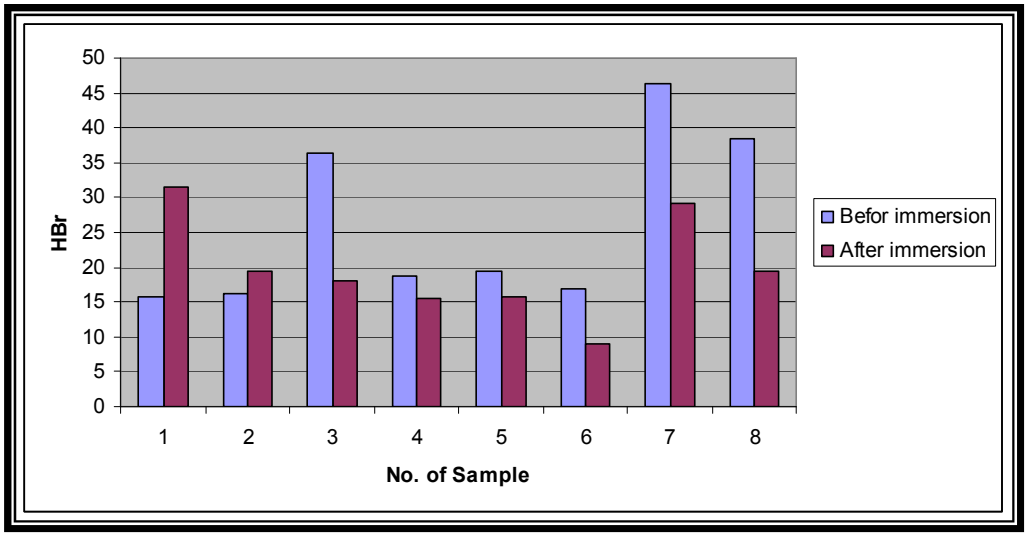

Figure (1): Changing the Brinell hardness before and after immersion

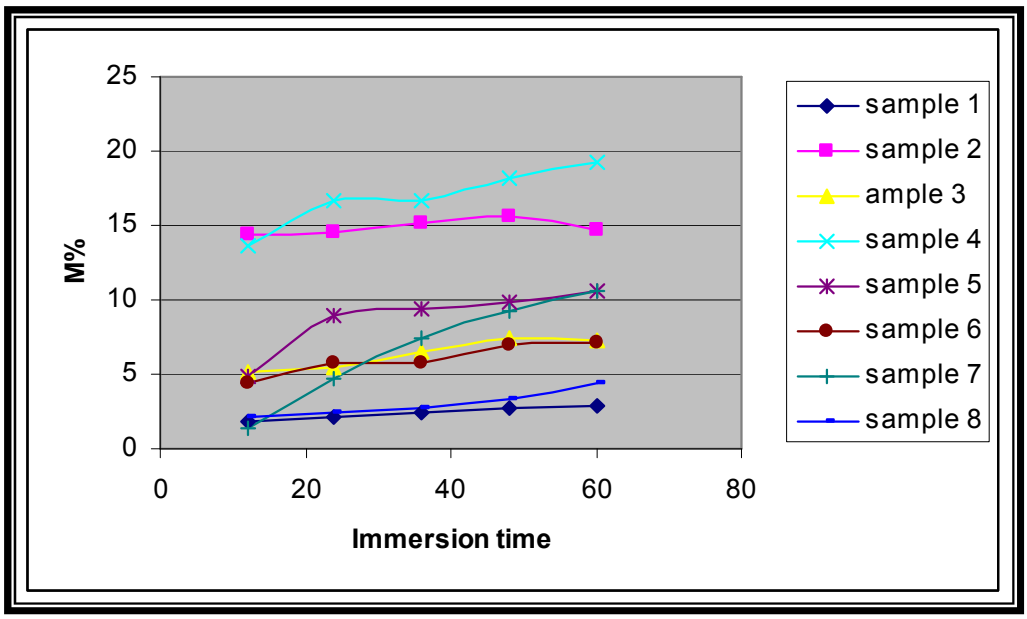

Figure (2): Changing the mass gain with immersion time.

Result and Discussion

Most of the favorable properties of thermosets are related to the existence of cross-links between polymer chains, and depend strongly on the cross- link density. The latter however is also responsible for the brittleness of thermosets, this brittle behavior can often limit applications for both the polymers them-selves and thermoset- based composites [9]. One of the most developed approaches is to blend a second tougher polymer with the fragile thermoset, the most popular systems have been epoxy resins modified by either rubber or thermoplastics able to undergo a phase separation during curing [10]. Brinell hardness was studied in this paper for epoxy resin (thermoset) which blended with phenolic resin (thermoset) in different ratio and comparing the results with the same blends reinforced with glass fibers.

The results show that the Brinell hardness of the epoxy increased when it blended with phenolic resin in small ratio, while the Brinell hardness started decrease with increasing the

amount of phenolic resin in the blend as it's obvious in table (1) due to the highest toughness of epoxy resin [4]. While the result show that the Brinell hardness of the samples increased after reinforcing with glass fibers making the composites which makes better mechanical properties than before because of the contribution of the applied loads will be on the blend, interface, and the glass fibers and the fibers will absorbed the most loads on the composites [11]. After immersion in distilled water the results show that the Brinell hardness of the epoxy and epoxy reinforced with glass fibers increased as a result of penetration of distilled water to the voids and cracks of these samples and cross- linking with the epoxy chains leading to increase in mechanical properties [12]. While the Brinell hardness of the blend samples decreased after immersion because of the degradation at the ends of polymer chains making the decreasing in mechanical properties [13].
From the results in table (3) is obvious that the sample (5) [Ep 80% +Re 20% +G.f] has maximum diffusion coefficient while the sample (2) [Ep +G.f] has minimum diffusion coefficient, this comparison between the two samples shows the role of phenolic resin in changing the absorption resistance of the samples through the hydroxyl groups of the phenolic reacted with epoxide groups of epoxy resins [5].

Conclusions

1. The Brinell hardness of the epoxy increased after reinforcing with glass fibers.
2. The brinell hardness of epoxy increased after blending with phenolic resin before and after reinforcing with glass fibers.
3. The Brinell hardness of the epoxy with and without reinforcing with glass fibers increased after immersion in distilled water.
4. The Brinell hardness of the blend samples decreased with and without reinforcing with glass fibers after immersion in distilled water.
5. The epoxy sample reinforced with glass fibers has minimum diffusion coefficient (maximum absorption resistance) which make them useful for container industry, while the epoxy – phenolic blend (Ep 80% + Re 20% + G.f) has maximum diffusion coefficient (minimum absorption resistance) means that this type of blend is not useful for container industry.

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