Effect of Some Environmental Factors on the Properties of Polyurethane/Silica Composites

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Abstract

Silica particles are directly introduced into polyurethane resin with different grain size and different volume fractions to obtain a new composite. Hardness, impact strength (charpy) and compression properties were studied with the conditions mentioned; Acid solutions and UV- radiation were the main environments studied on the samples prepared. The results showed that the acid affected the properties more than UV- radiation

1. Introduction

Organic – inorganic composites combine the advantages of organic polymers (flexibility, ductility, dielectric strength etc.) and those of inorganic materials (rigidity, high thermal stability, UV- shielding properties etc.) [1]. All properties depend on the strength and level of interaction between organic and inorganic phases, hydrogen bonding, vanderwaals forces and covalent-ionic bond between these phases.

From processing and application points of view, the mechanical and rheological properties of these composites are very important. These properties are related to materials microstructure, the state of dispersion, the aspect ratio, and orientation and interaction of polymer and particles [2]. In this paper the effect of micro silica particles (grain size and volume fraction) on some mechanical properties is examined and HCL solution was used with different morality (N 0.1, 0.3, 0.6) and UV- radiation using xenon lamp for different period (50 hr, 100 hr, 150 hr).

2. Experimental

The materials used in this work were polyurethane and silica powder with (specific gravity 2.1 g/cm^3). Applied to polyurethane resin with different grain size (Sieving) (50 µm, 75µm, 100 µm) and also with different volume fraction (15%, 20%, 22%) were mixed using hand made molding with dimension (20x20) cm then cut into dimensions of ISO and ASTM standards for impact test, compression and hardness. Some of the samples were immersed in HCl solutions diluted to several concentration with morality (0.1, 0.3, 0.6) N and some of these samples exposed to UV- radiation using instrument type (Weather meter zenotest 150). Polyurethane resin was chosen for wide range of hardness. Excellent wear and chemical resistance excellent adhesion, reverts in humidity [3].

3. Results and Discussion

3.1 Hardness property

Fig.1 Demonstrate the hardness (shore) of the polyurethane/Silica composites as a function of silicate diameter (50, 75,100), the best value was for 75µm, and composites built on this result was 20% silica with polyurethane.

The higher value of hardness because of the preparation method causes more polyurethane chains to be chemically bonded to micro silica particles as the hardness increases with silica content and the maximum hardness at about 75µm silica has more homogenous dispersion in the polymer matrix, **table 1** shows the values with different conditions of SiO_2 content.[4]

The UV–radiation using xenon lamp affected value of shore hardness caused some degradation on the surface of the specimens (breakage of some bonds). **Table (3)** showed values of hardness affected by HCL solutions (0.1, 0.3, 0.6) for optimum 20% volume ratio of SiO_2 composites the (0.3N HCL) had affected the specimens as HCL was an aggressive liquid caused degradation in polymer and caused a damage in the interface region between polymer and silica particles. **Figs. (2** and **3)** showed these conditions for hardness of the specimens.

3.2 Impact property

An impact test on specimens was carried out according to ISO- 179 using chirpy test with specimens of length 55mm and width 10mm and thickness 3mm [5]. Energy absorbed by the specimens are shown in **table 4** with silica fraction 20% and 75 μm diameter) and impact strength was calculated for each one.

From **table 4** the optimum value for impact strength was for 75 μm SiO_2 with volume fraction 20% in polyurethane. As this specimen was put in HCL solutions with different molarities and UV-radiation the result of these processes were shown in **table (5) Fig. (4)** and **Fig. (5)** Showed these conditions.

The UV-radiation for 50hr had increased value of impact strength (increasing toughness) of the materials and this may be caused by some chemical reaction caused the polyurethane more tough (by creating some free radicals) while for 150 hours the value decreased. Also the HCL solution decreased the impact strength as this aggressive liquid caused damage in the interface region of the composite this phenomenon was also noticed in Ref. [6] and [7].

4. Comparison Test

This test was done to evaluate the compression strength of the specimens and study the effect of environments UV- radiation and HCL solution) on this property, **Table 6** showed the affect of their condition on polyurethane and 20% SiO_2 by volume**. Figs. (6) and (7)** also showed these variations.

Composite strength is one of the mechanical properties which demonstrate the behavior of dispersion powder in the polymer matrix, the higher value of compression strength was for 75 μm grain size and the best reinforce with volume fraction 20% , values of compression strength depends mainly on the shear stress caused buckling in the specimens after taking barrel shape due to the elasticity in the material [8] also UV- radiation and HCL solution affected negatively in the values of compression strength [9,10] as UV- radiation is the main reason for breaking double bond in polymers in general.

5. Conclusions

1. The best values for hardness, compression and Impact were for 75 μm silica particles in the polyurethane resin.
2. SiO2 powder with 20% volume had the best values for mechanical properties studied.
3. UV radiation and HCL solution affected the properties mentioned above.
4. Exposure to UV radiation with (50hr) caused decreasing the hardness of the specimens due to breaking of some bonds at the same time Impact.
5. Strength was increased because same free radical was creates.

References

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Table 1: Hardness shore values with different condition of SiO_2 content.

SiO_2 particle diameter µm	Hardness Shore		
	15%	20%	22%
50	52	45	48
75	61	66	58
100	50	62	56

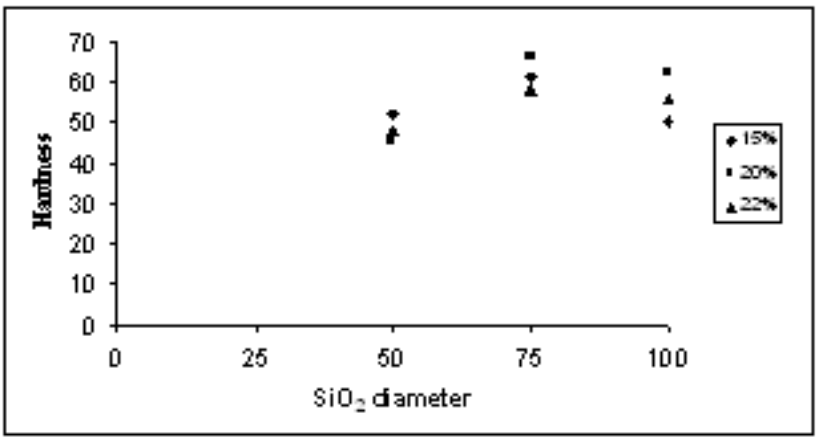

Figure (1): Shore hardness with different condition of SiO_2 particle

Table 2: demonstrates the effect of UV- radiation on the hardness values for optimum 20% SiO2 volume ratio of SiO2 Composition. [4]

Hardness shore	UV- radiation		
	50 hr	100hr	150hr
66	40	42	38

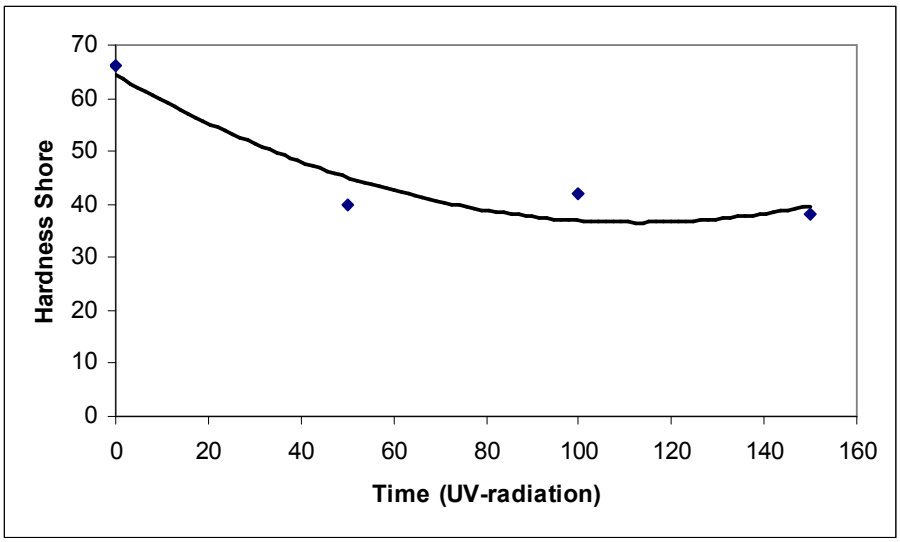

Figure (2): Effect of UV-radiation on hardness [4]

Table 3: Hardness shore values with different molarities of HCL solution for optimum 20% volume ration SiO_2 composition.

Hardness shore	HCL Solution		
	0.1 N	0.3 N	0.6 N
66	52	50	43

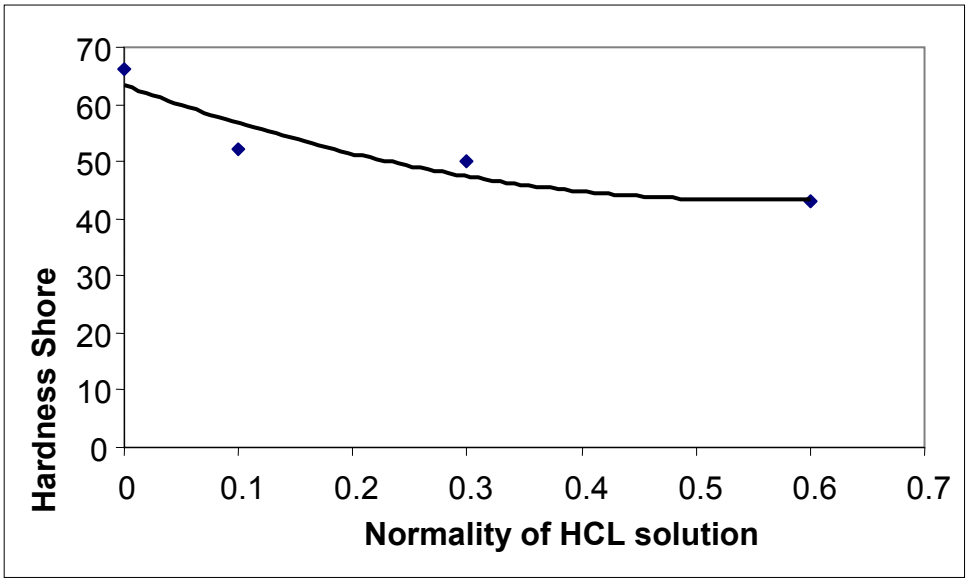

Figure (3): Effect of HCL solution with hardness

Table (4): Impact strength values with different condition of SiO_2 content.

SiO_2 diameter	Impact strength		
50	15%	20%	22%
	46	52	45
75	45	62	55
100	43	42	48

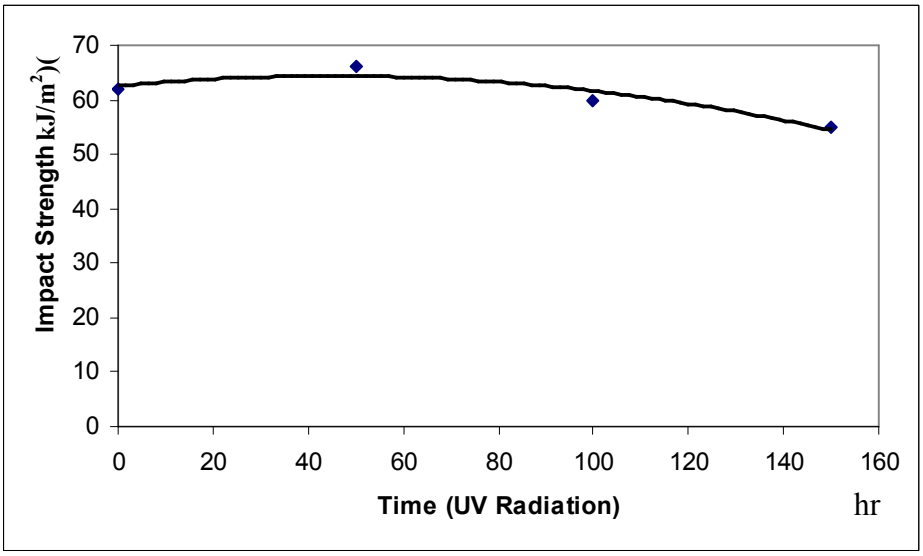

Figure (4): Impact strength with time UV- radiation

Table 5: Impact strength values with different molarities of HCL solution and UV- radiation.

Impact strength	UV- radiation			HCL solution		
0	50hr	100hr	150hr	0.1N	0.3N	0.6N
62	66	60	55	56	52	50

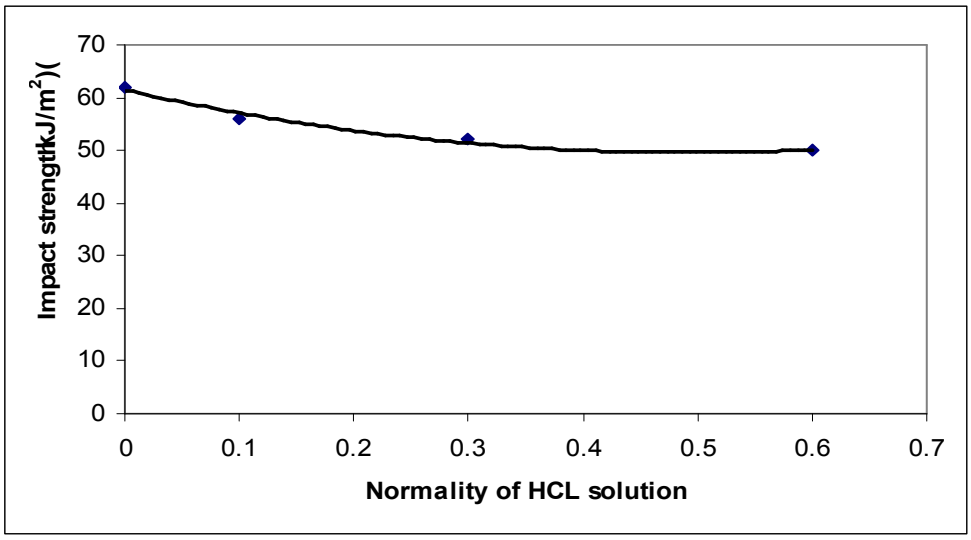

Figure (5): Normality of HCL with Impact strength

Table (6): Compression strength values with different molarities of HCL solution and UV-radiation.

Compression Strength	UV- radiation			HCL		
0	50hr	100hr	150hr	0.1N	0.3N	0.6N
12.3	14	10.2	9.8	11.2	10	8.3

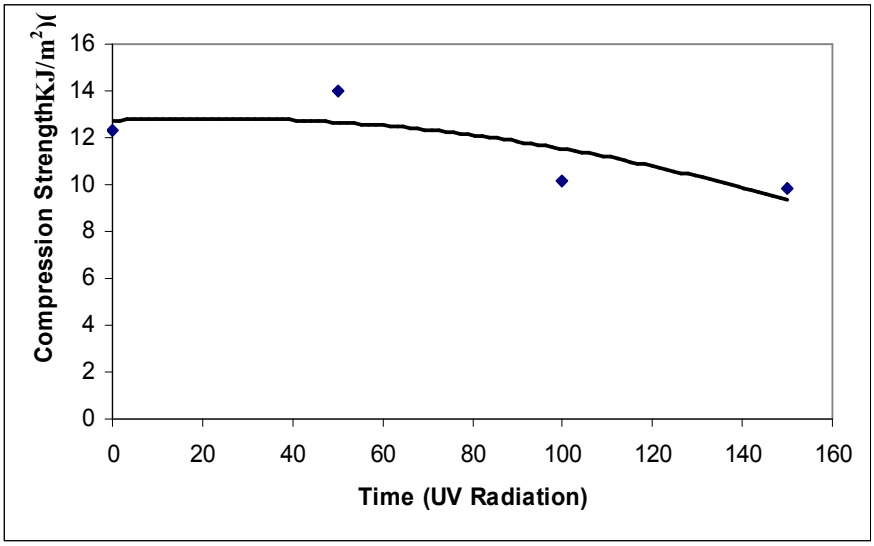

Figure (6): Compression strength with time UV- radiation

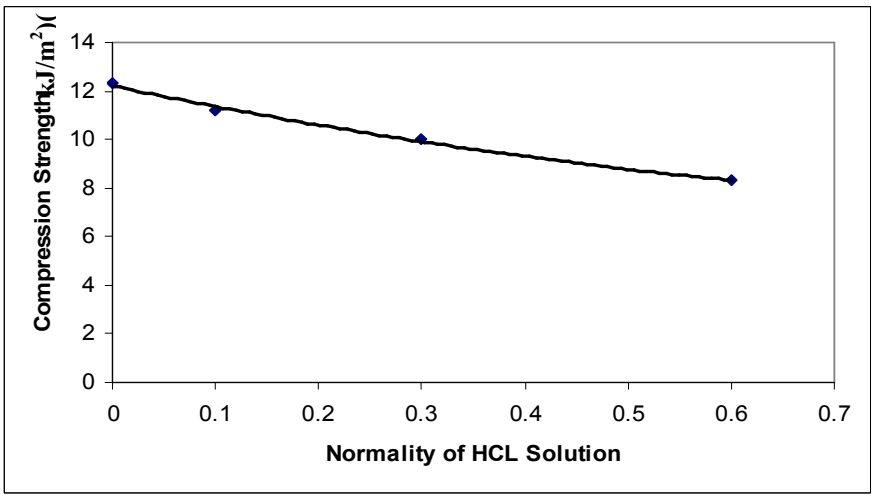

Figure (7): Compression strength with Normality of HCL solution.

تأثير بعض الخواص المحيطية على متراكب البولي يوريثين بأحجام ونسب حجميه مختلفة

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الخلاصة :

تم في هذا البحث دراسة تأثير إضافة دقائق السليكا إلى البولي يورثن بأحجام ونسب حجميه مختلفة والحصول على متراكب جديد ودراسة خصائص الصلادة ،الانضغاط ومتانة الصدمة (جاربي) للنماذج ثم دراسة تأثير الاشعه فوق البنفسجية والمحلول ألحامضي HCl بمعياريه مختلفة لكافة النماذج المحضرة. النتائج أشارت أن المحلول ألحامضي قد اثر على الخصائص بنسب اكبر من الاشعه فوق البنفسجية