Effect of environmental conditions on Shore hardness values of polymer blend

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Abstract

The current investigation was carried to study and determine the values of shore D hardness for polymer blends at different environmental conditions. Epoxy (EP) and Unsaturated polyester (UPE) resins were used to prepare polymer blends(EP/UPE) with various weight ratios (95/5)% , (90/10)% . After determining Shore hardness values, the specimens of both ratios of mixing were subjected to different environments included: sunlight for times (1,2,3,4,5) hours, the immersion into diverse types of waters (distilled, tap and rain) for the same previous periods for comparing the two cases. Other samples were immersed into the mentioned water kinds but for longer times (1,2,3,4) weeks. The results showed that the shore hardness values increase of both ratios after the subjecting to the sunlight at the above period while decease when the specimens were immersed into the different water sorts at the same period. The obtained results showed that the rate of dropping of hardness values was increased clearly at longer times of the immersion (4 weeks).

Keywords: Polymer blends, Shore hardness, sunlight, immersion

Introduction:

The field of polymer blends, or alloys, has experienced enormous growth in size and sophistication over the past two decades in terms of both the scientific base and technological and commercial development [1]. Since synthetic polymers are commercially important materials, it is in the interest of both the manufacturer and consumer to be aware of the degradative effect of commonly encountered conditions such as sunlight or high temperature [2].

Many polymers used in consumer products are degraded by UV light, and need addition of UV absorbers to inhibit attack, especially if the products are exposed to sunlight. The problem appears as discoloration or fading, cracking and sometimes, total product disintegration if cracking has proceeded sufficiently. The rate of attack increases with exposure time and sunlight intensity [2].

Epoxy resins are among versatile engineering structural materials. A wide variety of epoxy resins commercially available, but most are brittle. Several approaches have been used to improve the toughness of epoxy resins, including

the addition of fillers, rubber particles, thermoplastics, and their hybrids, as well as interpenetrating polymer networks(IPN_S) of acrylic, polyurethane, and flexibilizers such as polylos [3].

Hardness can be defined as a material's resistance to permanent indentation and Durometer is one of several scales used to measure hardness. Hardness has been well established in characterizing metallic material and ceramics for many years, but only recently has it been widely employed for characterizing polymers [4].

Pusz and Michalik examined the hardness of the high density polyethylene. After carrying out examinations, they concluded that the differences in the hardness on the diameter are caused by all sorts of contents of the crystalline phase; differences in contents of the crystalline phase are portraying the presence of inner stresses. This study indicated that the method of the cone it is possible to examine small samples and it allows for more exact measurements than different methods of examining the hardness [5].

Gao et al. prepared and characterizated of a Liquid Crystalline Epoxy(LCE) containing azomethine mesogen for modification of Epoxy resin. The results illustrated that improvement of physical properties of epoxy resin could be related to formation of self-oriented alignment of the prepared blend and microfibers formation in the network of cured epoxy resin. Therefore, it has potential application for modification
of epoxy resin [6].

Athawale and Alhousami studied the hardness of epoxy resin modified urea-formaldehyde/silicon blends, The hardness was found to be high in the case of modified epoxy resin as compared to blank epoxy. The results of the modified epoxy resins showed remarkably high thermal stability as well as a higher degree of solvent resistance as compared with blank epoxy resin [7]

Mustafa et al. synthesized and cured epoxy resin based on phenylhydroquinone using 4-aminophenylsulfone as curing agent Spectroscopic analyses (FTIR and NMR) were performed for product identification. Thermal, chemical stability and hardness testing were conducted on the cured and uncured product. The cured resin displayed an improved thermal and chemical stability compared to the uncured resin. Despite an improved hardness, the former is relatively brittle [8].

In this work, Shore D hardness test was curried out on (EP/UP) blends with different ratios (95/5)% and (90/10)% before and after subjecting them to sunlight for periods of time and after soaking them into the(distilled, tap and rain)water for different times. The aim of this study is determination the values of Shore D hardness of the prepared specimens that were subjected to these environments and comparing the obtained results from these conditions.

Experimental part:

1- Technique of samples preparation

Polymer blends with different weight ratios (95/5)% ,(90/5)% were prepared by mixing Epoxy(EP) resin with Unsaturated Polyester (UPE) resin respectively. Epoxy(EP) resin was supplied by [Don Construction Products (DCP) which commercially known as Quickmast 105, while Unsaturated Polyester (UPE) resin was supplied by (SIR)company, Saudi Arabia]. The addition ratio of hardener to the (EP)resin is (1:3) while to the (UPE) resin is (2%) with addition an accelerator material with ratio (0.5%) to the second resin. After the preparation process for each resin apart, these mixtures were mixed with each other and then were cast in a metal mould with dimensions (12, 10, and 3) cm^3 at room temperature. After solidification, the casting sheets were released from the mould and placed in an oven with (Temp.=50ºC) for (1 hour) to post-cure the castings. The specimens were cut from these sheets according to the specification (ASTM-D 2240). Fig.(1) shows photographic image of the prepared blend specimens with two ratios.

2- Hardness test

Shore Durometer hardness test apparatus (digital, Italy, type TH210) was used to measure the hardness values of the specimens under study, this tests were performed in air at room temperature and then repeated after exposuring the samples to the sunlight, (distilled, tap and rain) water for different times.
This test was carried out by fixing penetration tool of the Shore D apparatus on surface of the specimen, the number value of hardness exhibits on the electronic screen of the instrument as shown in Fig.(2).

Results and discussion:

The results of exposure of the samples to the sunlight are shown in Fig.(3). From this figure, it can be seen that the hardness values increases with increasing of subjecting time to sunlight through five hours, therefore the material under test became more brittle and harder, this result may be related to the increasing of cross-linking case between the polymeric molecules during this period of time [9]. It is worth mentioning that the polymer blend specimens under study were retained with their color after subjecting them to the sunlight for five hours.

Fig.s(4-6) show the influence of (distilled, tap and rain)water on the hardness values of the specimens under investigation after five hours of the immersion. It is important to show that the water enters the polymer by diffusion through the resin and by capillary action. The surface damage and cracks produced as a result of weathering further facilitate the entry of water. The previous studies indicated that the effect of water on the resin is to cause swelling and plasticiation-hydrolysis of resin is not considered to be an important process under the conditions encountered outdoors[10]. Other studies illustrated that in the Epoxies there are three important functional groups which can associate with water: (1) the hydroxyle groups formed when curing agents add across epoxide groups, (2) the phenelin ether groups which are present in all

bisphenol A or novolac based resins, and (3) the amino groups of the curing agents. On a molecular level, the effect of water associating with the groups mentioned is to decrease the hydrogen bonding between polymer chains which at the microscopic level is reflected in a plasticisation of the resin and then lead for weakening the mechanical properties of its [10,11,12]. Fig.(4,5,6) illustrate that the hardness values increases at the first stage of immersion and then return to decrease after this stage which indicates occurrence the plasticiation phenomenon that effects negatively on the measured hardness number. Fig.(7,8,9) indicates obviously that the drop rate of hardness values was increased at longer periods of immersion which indicates raising of water penetration rate through the molecular chains of polymer with increasing of exposure time [10].

Conclusions:

The effects of some environments on the hardness values of (EP/UPE) blend were investigated. The following conclusions could be drawn:

1- It is obvious that Shore D hardness No. of the (EP/UPE) blend increases after the exposure to the sunlight for five hours but decreases gradually after one hour of immersion in to the all types of water.
2- There is no clear cracks were observed for all specimens after subjecting them to sunlight or water but there is change in the color of the specimens that immersed into rain water only which became more soft and discolor.
3- At longer times of immersion, It can be noticed that all kinds of water have the same influence on the hardness values approximately.

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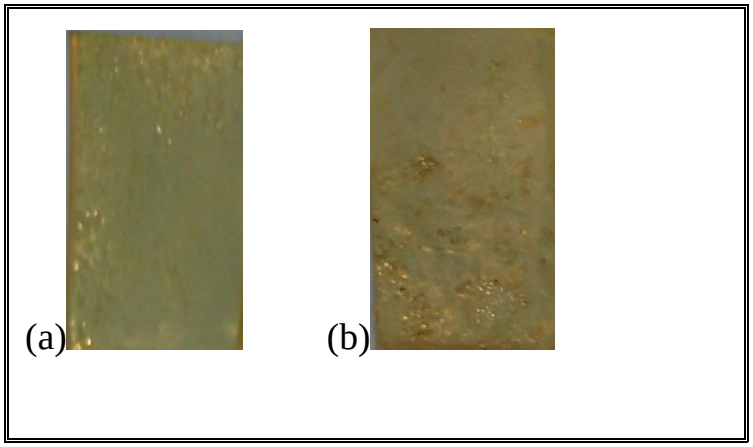

Fig.(1): photographic image of (EP/UPE) blends: (a) (95/5)% and (b) (90/10)%.

Fig.(2): Digital Shore D hardness apparatus.

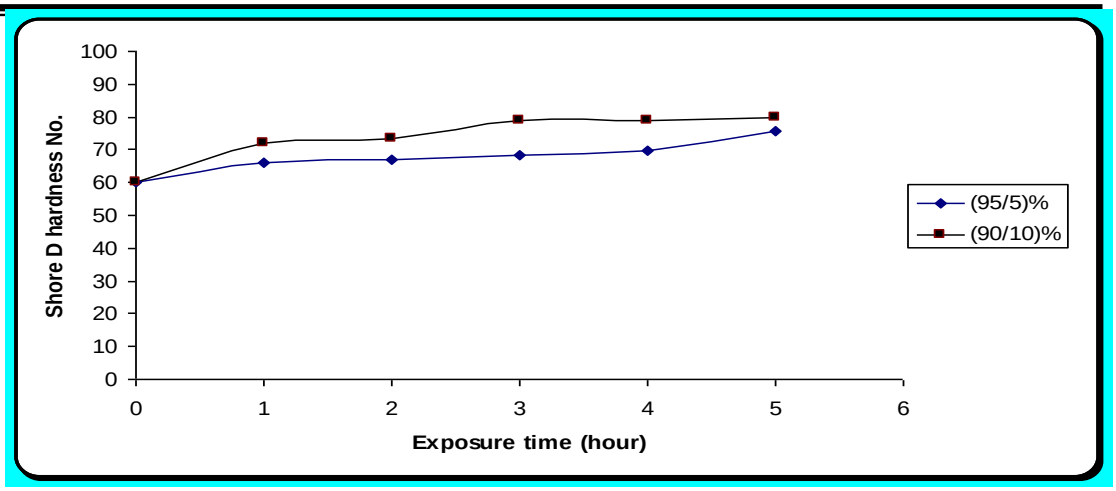

Fig.(3) Influence of sunlight on Shore D hardness No. of (EP/UPE) blends after 5 hours.

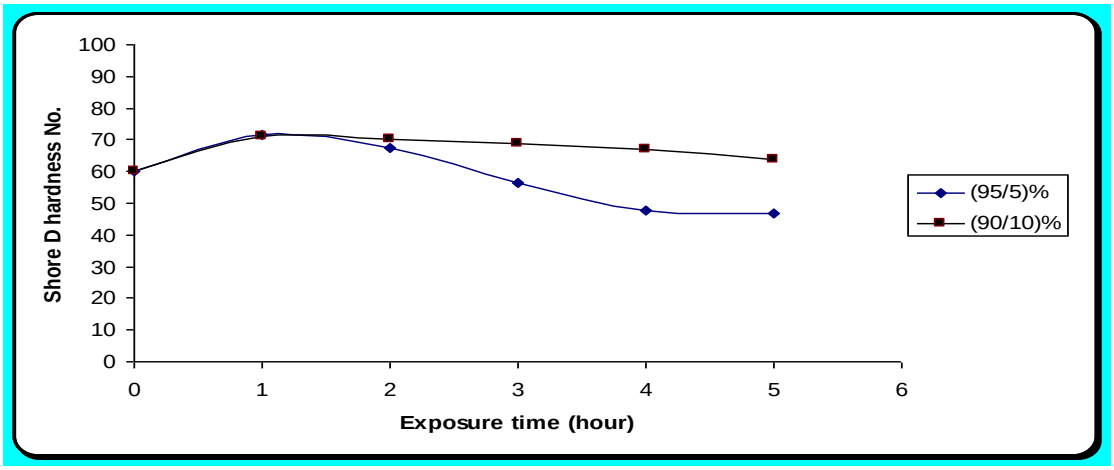

Fig.(4) Influence of distilled water on Shore D hardness No. of (EP/UPE) blends after 5 hours of immersion.

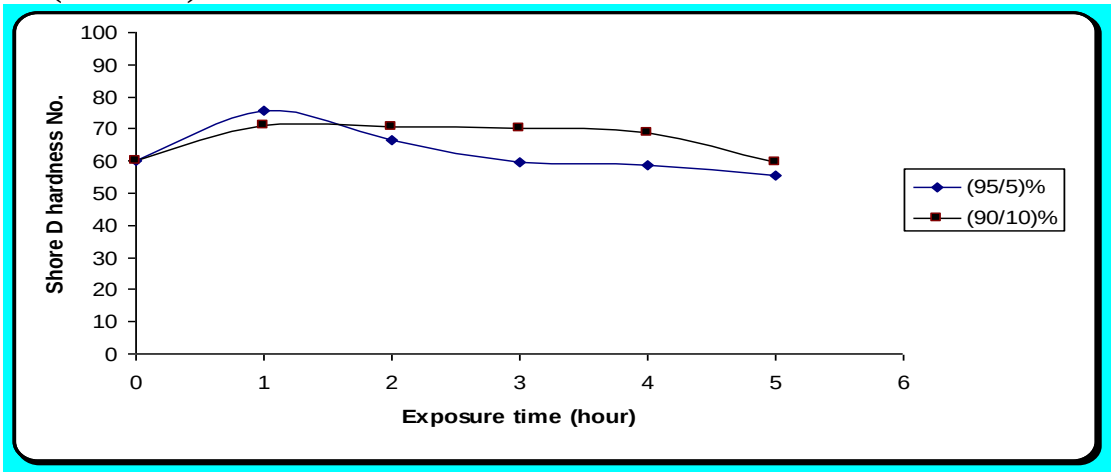

Fig.(5) Influence of tap water on Shore D hardness No. of (EP/UPE) blends after 5 hours of immersion.

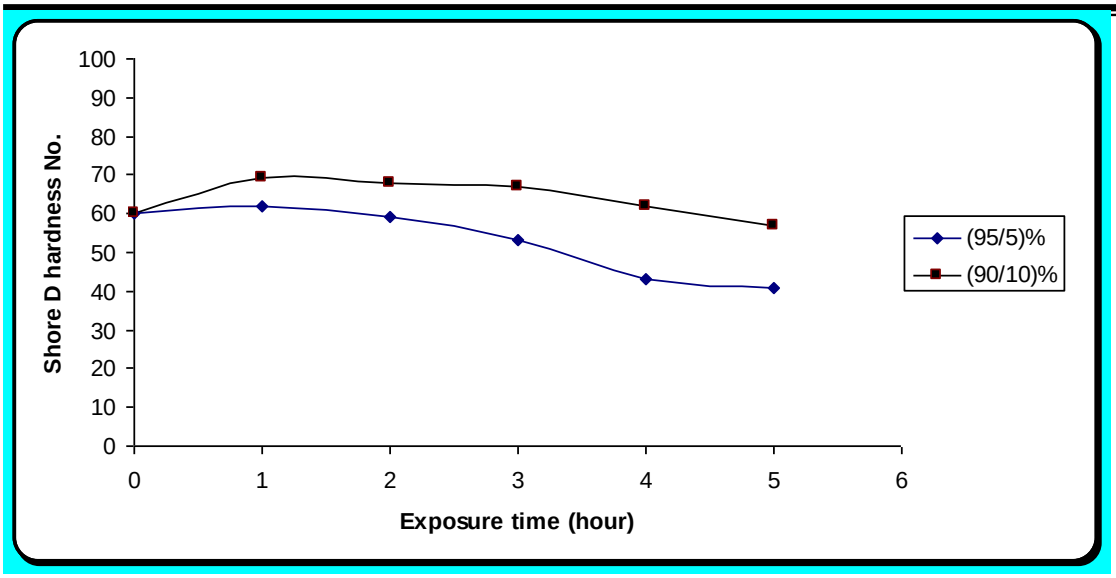

Fig.(6) Influence of rain water on Shore D hardness No. of (EP/UPE) blends after 5 hours of immersion.

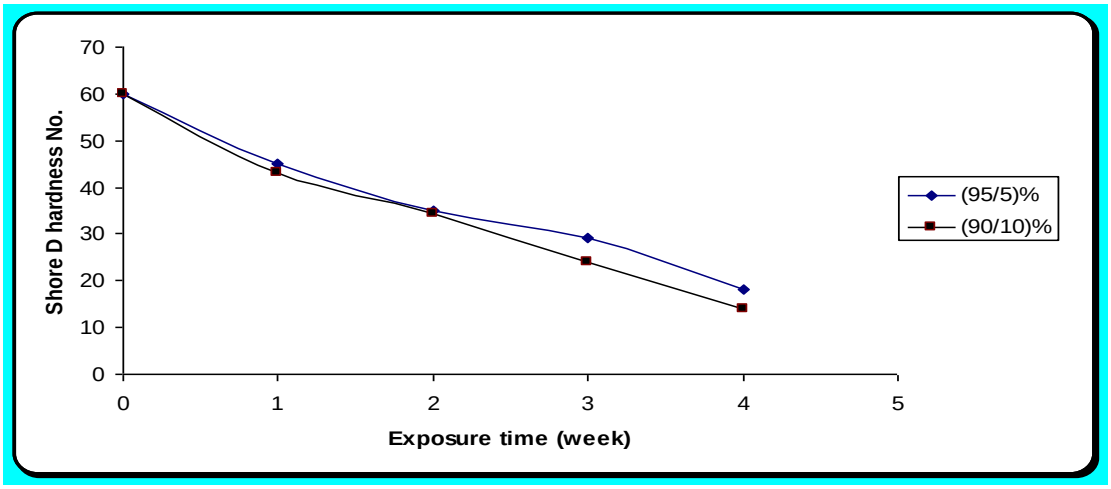

Fig.(7) Effect of distilled water after four week of immersion on Shore D hardness No. of (EP/UPE) blends

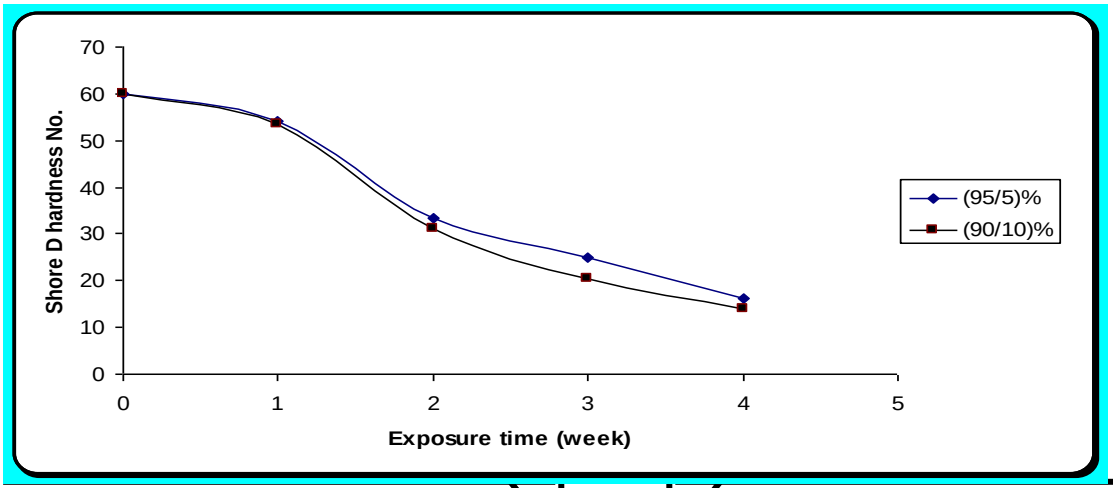

Fig.(8) Effect of tap water after four week of immersion on Shore D hardness No. of (EP/UPE) blends.

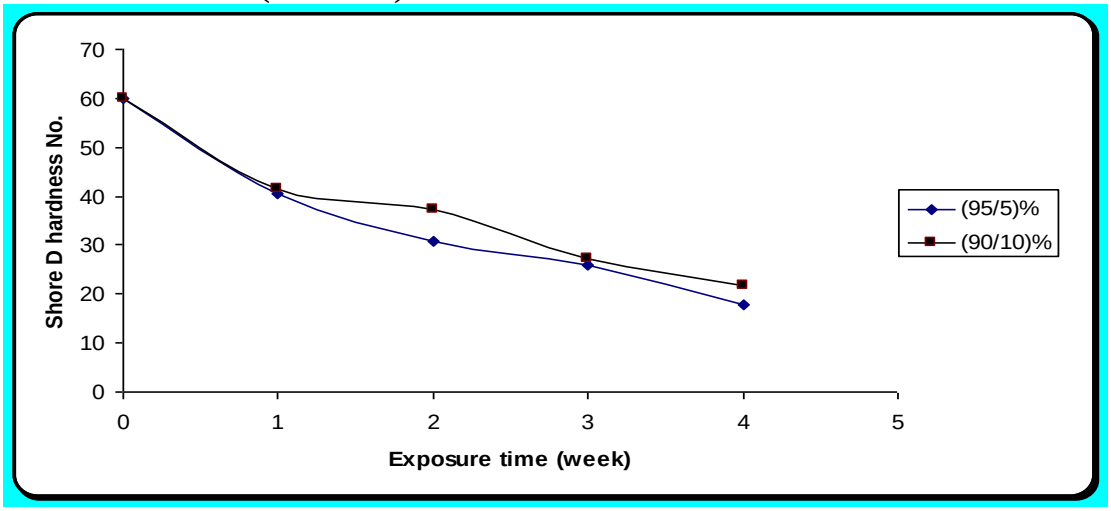

Fig. (9) Effect of rain water after four week of immersion on Shore D hardness No. of (EP/UPE) blends

تأثير الظروف البيئية على قيم صلادة شور لخليط بوليمري

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الخلاصة:

اجري بحثنا الحالي لدراسة وتحديد قيم صلادة شور نوع D لخليط بوليمري عند ظروف بيئية مختلفة حيث استخدم راتنجي الايبوكسي(EP) والبولي استر غير المشبع(UPE) لتحضيرخلائط بوليمرية من المادتين (EP/UPE) بنسبتين وزنيتين مختلفتين وهما %(95/5) , %(90/10). بعد تحضير النماذج وتحديد قيم صلادة شور لكلا النسبتين من الخلط تم تعريضها لبيئات مختلفة شملت ضوء الشمس لازمان (1,2,3,4,5) ساعة وكذلك الغمر في انواع مختلفة من المياه (الماء المقطر, ماء الحنفية , ماء المطر) لنفس الفترات الزمنية السابقة لغرض المقارنة بين الحالتين بعد ذلك غمرت نماذج اخرى في نفس المياه المذكورة ولفترات زمنية اطول

(1,2,3,4) اسابيع فوجد ان قيم صلادة شور تزداد لكلا النسبتين عند التعريض لضوء الشمس للفترة اعلاه في حين تتناقص عند الغمر في انواع المياه المختلفة ولنفس الفترة كما لوحظ من خلال النتائج المستحصلة تزايد معدل التناقص في قيم الصلادة بشكل واضح عند الغمر لفترات زمنية اطول ولمدة (4 اسابيع).