Characterization of the Influence of NaOH Chemical Solution with Different Concentration on the Properties of Nano-Composite Materials

Ibrahim A. Atiyah

Abstract—In this work, composites based on unsaturated polyester resin reinforced with nano-silica (0.5%, 0.7% and 1%) SiO2 were studied to determine the influence of sodium hydroxide (NaOH) chemical solution with different concentration (1%, 2%, 4%, 6% and 8%) wt. for a period of 24 hours under room temperature conditions on the mechanical properties of polymer matrix composite material. For this purpose, tensile and hardness taste were carried out. Since Polyester is one of most commonly used polymer matrix with reinforcing for advanced composites applications due to its low cost, easy handling, corrosion resistant, and flame retardant.

Index Terms—Composite Materials; Nano Materials.

I. INTRODUCTION

The particulate using of fillers in polymers has a wide history, and they are playing a very important role today. The composites with particles as reinforcement are called particulate composites [1]. If the matrix is a polymer, they are called particulate, polymer composites. Polymers, matrix composites are the most developed class of composite, materials [2] and have been accepted in a variety of aerospace and commercial applications [3]. The mechanical strength, modulus etc. are improved by incorporating mineral fillers into plastic resin. Distribution, size, and shape of filler particles are all elements on which the mechanical characteristics of particulate imbued with composites of polymer in the matrix of the polymer. As a way of improving electrical, mechanical, and thermal characteristics of polyester [4], the fillers that are particulate such as kaolin, talc, alumina trihydrate, mica, montmorillonite, silica, wollastonite, fly ash, and others are included. For improving modulus and stiffness and for decreasing costs of the fillers that are particulate, such as carbon black, CaCO3, and glass fiber are put together with the polymers. Properties that are tensile are affected by Fillers based on their interfacial bonding, characteristics that are packing, and size [5].

Nano-composites are polymers that contain nano fillers. The fine structure (in a metal or other material) which can be made visible and examined with a microscope of nano composites are not homogeneous in the nanometers scale scope. The materials that are nano composite materials occupies the scope between organic polymers and the glasses that are inorganic. There has been a use for the polymers fillers and the aim has been for enhancing the polymers performance, the rubber in particular [6]. By having the properties used, the nano composites have been proved to be remarkably useful. The literature that is technical and scientific reflect properties that are enhanced or improved related to the nano composite polymers in comparison with compared with the polymers that are pristine. This ambiguous condition is seen as the enhancement of the properties of the polymer in relation to the application of the polymer application [8] as well as to the unusual combination of the qualities that are nanomaterial which are mechanical and size qualities with low concentrations that are important to create a difference in the matrix of the polymer. By having the techniques of simulation and characterization, there would be much more interest in the nano composites field [7]. In addition, many nano composites polymers can be manufactured and performed in a series of operations in a similar way to the ones in the composites of the conventional polymer, having more attraction in relation to the perspective of manufacturing. Nano fillers like carbon, nano fibers (CNFs) or nano tubes, organoclay, or silica are frequently mixed with polymers that are foamed. This is done for various reasons, mainly the rising nucleation, the reduction in the size of the cell, and the improvement of the barrier properties [8]. It is often noticed that when adding nano fillers the mechanical qualities of the foams will be improved [9]. Polyurethanes that relied on the polycarbonate diols show mechanical qualities that are extremely good like the strength that is tensile, resistance that is higher and modulus towards the hydrolysis comparing with ones that are similar depending on polyesters. The qualities are exposed to a period of a process of mixing that is of a great intensity. This is due to the bonding of hydrogen between the groups of segment carbonate that are soft and the groups of segment urethane that are hard. Nano-composites that are based on polymer are polymers that are filled with particle and an aspect of particles distributed in different directions (more likely the phase of ceramics) is in the range of the nanometer [10]. The nano-composites qualities extremely rely on the matrix that is organic, content nanoparticles, size they have and their shape, as well as the way by which a nanocomposite is prepared. Currently, many details are reported concerning the relationship between property and composition as well as the effects of adding different clays on the properties that are thermal, the properties of polyurethanes that rely on diols of polycarbonate with Mw that is about 1000 [11].

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I. A. Atiyah is with Al- Mustansiriyah University, Faculty of Engineering, Material Engineering Dept., Baghdad, Iraq. (e-mail: ibrahim1980@uommustansiriyah.edu.iq)

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II. EXPERIMENTAL WORK:

A. Materials

1) Unsaturated polyester

Unsaturated polyester is shaped in the design of a liquid of transparency and high viscosity under temperature at the room and is kind of polymers that is made solid in thermal ways (Thermosets); it is solidified by putting Hardener MEKP (Methyl Ethyl Keton Peroxide) which is on liquid that has transparency and it is put by the shape (2g) to (100g) of polyester resin that is unsaturated under tempt. in the room. (Styrene percentage is 32; when viscosity is at 25 ºC, it will be 1000 cups; the appearance is transparent; the solid basis of is 22; the gravity is specific and it is 1.15). By finishing the process of adding catalyst and Hardener in the mix of the resin, this process of mixing starts acting as a medium in mixing done with the hands which lasts between 8 to 10 minutes until the mixture becomes in harmony. When it takes more than this time, a mixture will be with high viscosity causing a rising in the temperature. Ultimately then, this will lead to the process that is hardening to undergo a change in velocity and this impedes the process of casting and product coming at the end of this series to have high bubbles in the air [12].

2) Nano silica

Nano materials used in this study are given in Table I.

<table>
<thead>
<tr>
<th>Properties of Nano-Silica</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter (nm)</td>
<td>8-18</td>
</tr>
<tr>
<td>Percentage of Purity (%)</td>
<td>98</td>
</tr>
<tr>
<td>Surface area (m²/g)</td>
<td>240</td>
</tr>
<tr>
<td>Rate of Density (g/cm³)</td>
<td>0.5</td>
</tr>
</tbody>
</table>

B. The Preparation of Mould

The moulds required for preparation of the samples of the test were made from acrylic having the dimensions of (250*25*2.5) mm as seen in Fig. 1. In order to keep away from the sticking between the moulded wall and the material that is cast, a wax layer having thinness will cover the walls that are internal.

C. Test specimens Preparation

The steps of test specimens preparation are explained as follows:

a- The fillers used was with percentage 0.5%, 0.7% and 1%, from the weight to the mixture and mix for tow minute in glass rod.

b- By avoiding the formation of bubbles that result in the physical hard that is cast, the mixture was added into the mould from the corner and pouring that is the same in all cases and time continues until filling the mould to reach the needed level.

c- To get rid of any remaining parts of bubbles, the mould was shaken by hand (i.e. gases that were captured and turning from liquid into vapor at the time of mixing and the rising of the temperature). This is also done to keep the process of the cast distribution of in the mould.

d- For 24 hours the mixture has been kept in the mould under temperature of the room in order to be solidified.

e- All samples put in furnace (60 c) for (3-4) hrs to get the final toughness.

D. Tensile Test

This test performed by using universal tensile test based on (ASTM-D 3039) under the temperature of the room with dimensions of (250*25*2.5) mm, the result of this test are shown in the following figures [13].
III. RESULTS

According to the previous stress-strain diagrams which result from tensile stress according to ASTM-D3039 we can conclude the following figures which summarize these results, from which, it is clearly that tensile strength increase with the rise of nano silica thigs contained also with the increase of the concentration of NaOH chemical solution.
**Hardness Test**

This test is carried out and fulfilled by using the hardness of shore (D) Fig. 5. Hardness can measure the plastic deformation for the materials that suffered under external applied stress. By using Shore-D hardness test device in which, the sample surface must be very flat, diameter of the samples is more than (30 mm) with a layer of thickness more than (3 mm) [13]. The results of this test are shown in following figures. The effectiveness in the increase of the percentage of nano silica and the concentration of NaOH is clear in the increase of hardness of the nano-composite polymeric material.

**IV. CONCLUSION AND DISCUSSION**

In general, the effect of nano silica content with the concentration of NaOH chemical solution lead to improve the mechanical properties of nano silica- polyester composite material.

For hardness, the best nano silica percentage is of 0.5% and 1% which increase the hardness clearly with different concentration of NaOH. While for tensile strength, the increase of nano silica content increase this property by the increase of NaOH concentration.

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