Mistudy the Effect of Physical Properties of Polyester - Fiber Glass

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Abstract: The solubility and kinetics of moisture transport mechanisms in type of resin and fibers have been investigated the physical tests group comprised the determination of diffusion coefficient (D) of water, (0.5N HCl), (0.5N H2SO4). In this study has been oriented to investigate a theme that has a crucial interest in most industrial applications, also the effect of water, HC1 and H2SO4 on the composites. The composite plate contains two type of fiber the first type polyester-woven and random fibers the type two from: polyester–random fibers. The result shows the solution would be absorbed in the first type more than that in second type and it is shown that water acts as a plasticizing agent for these materials, but solution has led to the degradation and deterioration of the (UP) blend, while acidic solution has no notable effect on the composites.

Key words:

INTRODUCTION

The diffusion and solubility characteristics of H2O and other molecular species in composite materials have been discussed in numerous papers, mostly on studies conducted in the last fifteen years (Sacher, E. and J.R. Susko, 1979; Sacher, E. and J.R. Susko, 1981; Sacher, E. and J.R. Susko, 1979; Sacher, E. and J.R. Susko, 1982). These investigations have highlighted the limited understanding of the actual solution and transport processes in resins and resin-glass composites, particularly the role of chain chemistry and sinks, i.e., chain sites or cavities, in affecting the sorption-description process. Materials are pore-free is activated diffusion. The process by which permeation occurs when these materials are pore-free is activated diffusion. The molecules dissolve in the surface of a polymer, equilibrating with the atmosphere, establish a chemical potential, and diffuse in the direction of the gradient. Thus two fundamental properties are of interests which lead to an understanding of the phenomena. The first of these is solubility (c), which is related to the partial pressure (P) through Henry's law (c = yP),

where y is an activity coefficient.

The second property is the diffusion constant (D), which is the ratio of the molecular flux (Q) divided by the gradient of the concentration (dc/dx) of the diffusing species, i.e., Fick's law, Q = D dc/dx. These parameters can be evaluated as functions of concentration and temperature, (Bair, H.E. et al., 1978.) the diffusion coefficient normally increases with concentration. This has been discussed as a plasticizing effect and is often accompanied by a decrease in glass transition temperature Tg. Although this behavior is exhibited by H2O in some composites, a more common behavior appears to be decrease in the diffusion coefficient with increasing concentration.

2. Experimental Setup
2.1 Materials

Unsaturated Polyester:

It is most widely utilized and least expensive polymer resins. This matrix material is used primarily for glass fiber-reinforced composites. A large number of resin formulations provide a wide range of properties for this polymer (http://www.camt.usyd.edu.au/education/MECH3300/Lecture7/lect ure7.htm).

The density of unsaturated polyester used in the present work was 1.19 gm/ cm³. The hardener used with UP was methyl ethyl ketone peroxide (MEKP) in the ratio 2wt.% and activated cobalt octate(0.5wt.%) as accelerator.

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Glass Fiber-Reinforced Polymer (GFRP) Composite:
Fiber glass is simply a composite consisting of glass fibers, either continuous or discontinuous contained within a polymer matrix, this type of composite is produced in the largest quantities. The composition of the glass is most commonly drawn into fibers, fiber diameters normally range between \(3\) and \(20\) m. Glass is popular as fiber reinforcement material for several reasons (Ing-Nan Jan, et al., 2005):

- It is easily drawn into high-strength fibers from the molten state.
- It is readily available and may be fabricated into a glass reinforced plastic economically using a wide variety of composite-manufacturing techniques.
- As a fiber, it is relatively strong, and when embedded in a plastic matrix it produces a composite having a very high specific strength.

<table>
<thead>
<tr>
<th>Table 1: Properties of E-glass</th>
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<tbody>
<tr>
<td>Strength</td>
</tr>
<tr>
<td>2</td>
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</table>

Table 2: Samples dimensions and standard Specifications for the testing specimens.

<table>
<thead>
<tr>
<th>Test</th>
<th>Sample dimensions</th>
<th>Standard Specifications</th>
</tr>
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<tbody>
<tr>
<td>diffusivity</td>
<td>10mm x 10mm</td>
<td>ASTM-D3570</td>
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</table>

2.2 the Balances Instruments:
The sensitive balance was utilized; an electronic with four digits, which was used to measure the weight of the samples that used for diffusivity test fig(1). The weight change (%) of the diffusivity samples after each period of immersion is calculated from the relationship:

![Fig. 1: Sensitive balance.](image1)

2.3 The Test Specimens:
The test specimens were two types the type one from: polyester-woven and random fibers the type two from: polyester-random fibers fig (2) shows the test specimens in Water, HCl and H2SO4 solutions for two types

2.4 Diffusion Coefficient Measurement:
Calculate diffusion coefficient in the polymeric to blend and in composite material.
The balance is also an electronic type AE 160/4 Digits manufactured by (Metler/England) with four digits. It is used to measure the weigh of the samples that are used in diffusivity test as shown in Fig. (1).
The weight change (%) of the diffusivity samples after each period of immersion is calculated from the relationship.

![Fig. 1: Sensitive balance.](image1)
Weight gain \% = \frac{W_2 - W_1}{W_1}

where:

- \( W_1 \): weight of immersed specimen.
- \( W_2 \): weight of dry specimen.

The diffusion coefficient \( D \) is calculated from the equation (Fick's second law):

\[
D = \pi \left( \frac{KT}{4M_m} \right)^2
\]

Where:

- \( K \): the slope of straight line of the curves, which represent the relations between the weight gain percent (\%) and square root of time \( (\sqrt{t/\rho}) \).
- \( t \): the thickness of the specimen.
- \( M_m \): the apparent maximum water content (the saturation level).

**RESULTS AND DISCUSSION**

Fig. (3-5) shows the percentages of the solutions that are gained by composites with two types of E-glass. From these figures, it is quite clear that solution would be absorbed in the first type of composites more than that in second type of composites. Because that the fiber/matrix interface plays the role of a channel for a solution to penetrate into the composite; this penetration normally starts at cut edges. This type of channels found in the composites, which means the gained quantity of solution by composites, is more. And the composites which contain glass fibers would undergo stress-corrosion resulting from the leaching out of the network modifier, from the glass structure. This sort of stress corrosion occurs more rapidly in acid or alkaline environments than that in water alone. It is clear, that this phenomenon is confirmed by this work. Both above mentioned two mechanisms look logical, but it is essential to add, that the existence of micro cracks, flaws, voids or any other in-homogeneity in the blends and composites would enhance the process of penetrating of the solution into those materials, therefore, fewer defects and more homogeneity would definitely lead to reduce the absorbed solution by these materials.

Fig. (3-5) also clearly shows that water, HC1 and H2SO4 solutions wick into type 1 of composites more than they are drawn into type 2 composites, this is, due to the textural nature of the fibers (woven)or (woven-random), which give addition channels to the solution to permeate into this composites through the fiber itself. This leads to the conclusion that such sorts of environments must be avoided when composites are used.

The diffusivity coefficients of H2O, HC1 and H2SO4 in the composites are calculated, according to the second Pick's law. The results are shown in Table (3). From this table, it can be seen, that the diffusivity coefficients of water in the materials (under test) has increased compared with that of pure matrices, due to
the interface defects or in-homogeneity that exists in the blends and composites. The same idea can be built for HCl and H2SO4 solutions, due to the same reason. The same table shows that the diffusivities of water and HCL, in composites are more than their identical in H2SO4 because polyester has high resistance to acids as is known. The diffusivity coefficient of water in UP s is larger than that of HCl and H2SO4. This result agrees with Caddock and Evans who found that the diffusivity of water in polyester is much more than that of HCl.

Table 3: Diffusion coefficient of the blends and their composites

<table>
<thead>
<tr>
<th>Specimen</th>
<th>diffusion coefficient (D) Polyester resin and e-glass fiber</th>
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<tbody>
<tr>
<td></td>
<td>H$_2$O</td>
</tr>
<tr>
<td>Type 1</td>
<td>0.066</td>
</tr>
<tr>
<td>Type 2</td>
<td>0.003</td>
</tr>
</tbody>
</table>
Fig. 5: Weight gain% of composites in H2SO4a as a function of time squared.

Conclusions:

Water, HCl and H2SO4 solutions normally diffuse through thermoset composites. The diffused quantity of solution would depend on the nature of the resin, type of solution and on the conditions of the exposure (temperature and relative humidity). The selection of any material, for specific application, can not be made without finding out the effect of the environment on the characteristics of the selected material. The considered composites are destined to be used in a wide scope of applications, such as automotive, construction, chemicals and petroleum plants. This means that those materials could be exposed to humid, acidic, or alkaline environment. Therefore, the effect of such conditions on the composites must be investigated. These materials were soaked into three containers of H2O, (0.5N) HCl and (0.5N) H2SO4 for seven weeks to study the diffusivity behaviors of such solutions into these materials.

REFERENCES