

Investigation of Physical, Mechanical, and Morphological Properties of Acrylonitrile Butadiene Styrene on Unsaturated Polyester Resins

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Abstract: Thermosetting resins are among amorphous Unsaturated Polyester Resins (UPR) which due to having high cross link are widely utilized. These resins are involved beneficial proprieties such as high modulus and strength, their physical and mechanical properties are shown a good resistance against high temperatures due to their stiffness and the high density of their cross link. The obtained results show that with adding Acrylonitrile Butadiene Styrene (ABS) decreases tensile strength and modulus, and increases the percentage of elongation at break as well as the toughness of UPRs. As observed in the bending test, the maximum bending reaches to 4.460 MPa and for tensile test the maximum reaches to 63.217 MPa. The morphological analysis of Acrylonitrile Butadiene Styrene on heated composites shows a two-phase system which causes rubber particles to be dispersed in resin matrix. This study introduces Acrylonitrile Butadiene Styrene in order to investigate physical, mechanical, and morphological properties on unsaturated polyester resins. As unsaturated polyester resins resistance against cracking and toughness is low, in order to overcome in these disadvantages, Acrylonitrile Butadiene Styrene was added and mentioned disadvantage largely improved.

Keywords: Unsaturated Polyester Resin, Toughness, Acrylonitrile Butadiene Styrene, Morphological Properties

I. Introduction

Unsaturated Polyester Resins (UPR) are manufactured by condensation reaction between acids like Isophthalic Acid, Phthalic Anhydride, Maleic Anhydride and glycols like Propylene Glycol, Di-ethylene Glycol, Mono-ethylene Glycol, etc and are widely utilized in composite industries. Over the recent years, the application of polymer composites has been expanded in various fields remarkably including automobile manufacturing, aviation, navy, and military. This growth has an increased demand for most of thermosetting resins such as (grades) unsaturated polyesters. The applications of these resins are due to their reasonable price, the large variety of existing grades (T_g), the beneficial composition of used materials and the simplicity of their processing. The crazing which occurs in such resins is due to the growth of cracks and defects. The defects are including inner cracks, surface cuts, and tiny bubbles which are caused by the used method in the process (1, 2). Another used method for increasing the toughness of UPRs is involving a modification in the chemical structure of the resin. For instance, common glycols in preparing the polyester resins can be replaced with cross-linked glycol ether (e.g. di ethylene glycol, propylene glycol, and glycol with aliphatic chains), 1,4 Butanediol, and 1,6 Hexanediol, to enhance the flexibility of resins. While UPRs, to be combined with rubbers, show a remarkable decrease in shrinkage during casting, besides an increase in shock resistance. Casting is the most important use of the treated and improved UPRs with rubbers, which can be used in automobile manufacturing industry. UPRs, can be improved with different types of rubbers which are themselves divided into three types depending on their solubility and mix ability with UPRs. (3, 4, 5) These rubbers show well adjust ability with UPRs and are solved in them during the mixing process. The importance of solubility refers to this fact that some fine cohesiveness can be reached in the aggregate of particle matrix (6, 7). The ABS co- polymer is one of the most widely used types of plastic in engineering which is including a rubber composite. The chain of ABS is almost the most important product in polymer industry in Taiwan. This change involves two co- polymers glass phases of poly styrene acrylonitrile and poly butadiene rubber (8). Poly butadiene latex is normally generated through the emulsion polymerization. The rubber piece of poly butadiene (PB) is composed of a rubber phase and exists as a spherical particle in the glass matrix of styrene acrylonitrile (SAN) (9). Styrene acrylonitrile is joined with poly butadiene through emulsion polymerization, to enhance the resistance of plastic against collision. Glass copolymer can be composed of different combinations, while its resistance is enriched with an increase in the amount of acrylonitrile or styrene. Yet, copolymer containing poly butadiene (PB) is vulnerable against photon oxidation and oxidative damage. Oxidation damage not only obliterates mechanical properties, but also it is a hazardous agent in producing ABS powder. Previous studies indicate that thermal oxidation of ABS occurs in the phase of tri polymer poly butadiene (PB). When the amount of hydro peroxide increases, the rubber part starts to show vulnerability against oxygen. Also, the process can obliterate the especially elastic network link in the rubber phase, reducing the resistance of the ABS polymer against photon oxidation and thermal oxidation.

Shimada and Kabuki has been performed IR spectroscopy studies on the oxidation of ABS at temperature 70-90 °C. (10). This study aims to investigate physical, mechanical, and morphological properties of acrylonitrile butadiene Styrene on Unsaturated Polyester Resins and the main objective of this work is to evaluate this polymer to improve UPRs.

II. Materials

In this study, Epoxy Mark resin produced by Bushehr Chemical Industries was utilized. The used UPR is orthophthalic S65-74425 Bushepol, and the ABS was prepared from the South Korean company Samsung & Chell. Methyl ethyl ketone peroxide was used as the catalyze in heating the resin, and the Cobalt Naphthenate MEKP accelerator was utilized which was produced by Dutch Akzo Nobe company.

III. Methodology

These materials with their corresponding amount were used in this investigation: 150 gr unsaturated polyester to prepare the sample and performer of the mechanical tests was used, two weight percent of cobalt (II) naphthenate as accelerator, two weight percent of Methyl ethyl ketone peroxide as catalyze, and 25 gr ABS. After the mixture was thoroughly solved, it is cast in mold. The resin was heated for 12 hours at the environment temperature, and after this time the sample was separated from the mold. After that, it was heated one more time in vacuum oven in the temperature of 80 °C. Vacuum oven was used in order to remove the bubbles and empty spaces in the sample. The samples were then mixed for 20 minutes at 60 RPM by an appropriate mechanical mixer to become well homogenized. While the existence of styrene in ABS, are added to the base of the UPR, it would accelerate the process of co - polymerization in the sample. Four samples to perform the mechanical and physical tests were prepared.

IV. Results and Discussion

A. Mechanical properties of UPR base on S65-74425 Bushepol

To determine the degree of toughness and compare various methods of toughening, it is primarily necessary to measure the mechanical properties of UPR in order to have basis for comparing it with its toughened form. Table 1 shows the results of the mechanical properties of the resin S65-74425 Bushepol.

Table 1: Mechanical properties of the unsaturated resin base S65-74425 Bushepol

Test	Standard	Amount
Tensile strength	ASTM-D-368	65
Elongation	ASTM-D-368	1.44
Tensile modulus	ASTM-D-368	4
Toughness 103	ASTM-D-368	94
Impact test	ASTM-D-265	55.5
Stiffness	ASTM-D-2240	89

B. Effects of the mechanical and physical properties with an increase in ABS on UPR

The four samples were used for mechanical and physical tests, as are shown in Table 2.

Table 2: Tensile test on UPR treated with ABS

Sample	Max tensile (MPa)	Fraction (mm)	Velocity (mm/min)	Elastic modulus (MPa)	Yield point (mm)	Max yield point (MPa)	Energy (joule)
1	39.317	1.897	5	528.053	1.611	137.970	1.434
2	50.847	2.128	5	467.503	1.821	168.458	2.023
3	54.060	2.903	5	466.473	1.563	217.992	3.073
4	63.217	3.833	5	52.129	3.038	270.068	5.189

V. Samples Properties

A. Mechanical tests: bending, tensile, impact

A1. Bending Test

This test can be useful for determining quality control and properties. The bending properties of resins are not only important to components manufacturers, but also for designers. The tensions engendered in the sample are a combination of pressuring and stretching tensions. In thick samples cutting forces also come to play. Bending properties are determined through the stresses and strains occurring at the surface of the sample. One of the advantages of the bending test compared to other tests (tensile) is high-rating transformations in low-stress conditions and its facile measurement. In Figure 1, the maximum of bending is 2.921 MPa, while this bending will undergo transformations in other figures according to the arrangement of its percentages and gradually starts to increase. In Figure 2, the maximum of bending reaches 3.642 MPa, while under close inspection , one

can discover that the elastic modulus considerably increases. In Figures 3-4, the maximum of bending reaches 3.829 MPa and 4.460 MPa, respectively.

A2. Tensile test

Tensile test was performed according to Standard ASTM D638 through the use of ZWICK 1458 tensile machine, under environmental conditions at 10 RPM and room temperature. In Figure 5, the maximum of tensile is 39.317, while this value reaches 50.867 MPa. In Figures 7-8, the degree of tensile is 54.060 MPa and 63.217 MPa respectively.

A3. Impact test

The Izod impact test was performed on the samples without Nutch, 256, through the use of the Toyoseiki impact machine at room temperature according to Standard ASTM

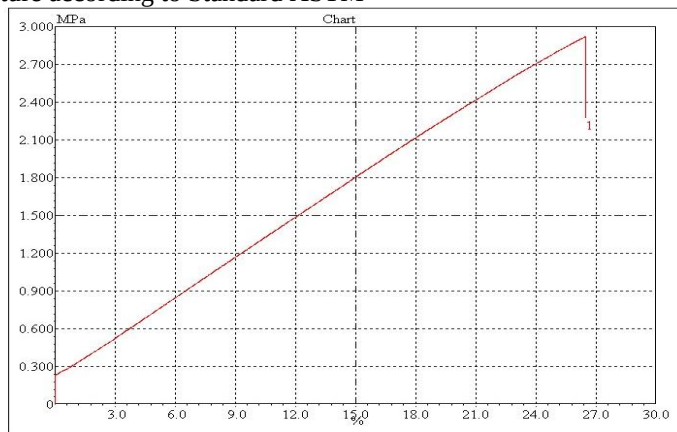


Figure 1: Bending test on Sample 1 of UPR treated with ABS

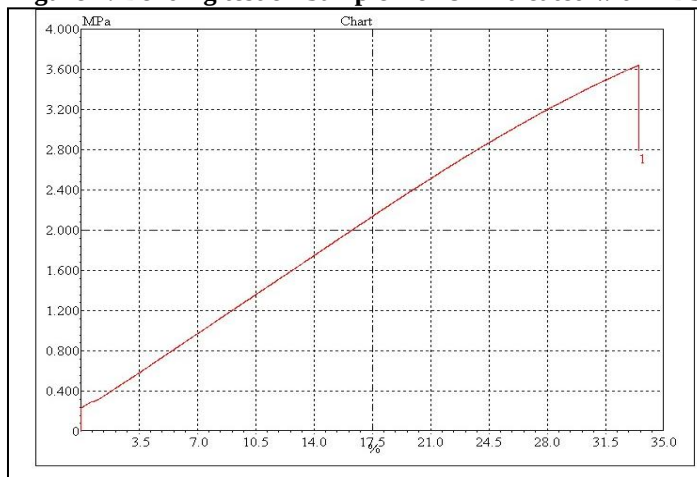


Figure 2: Bending test on Sample 2 of UPR treated with ABS

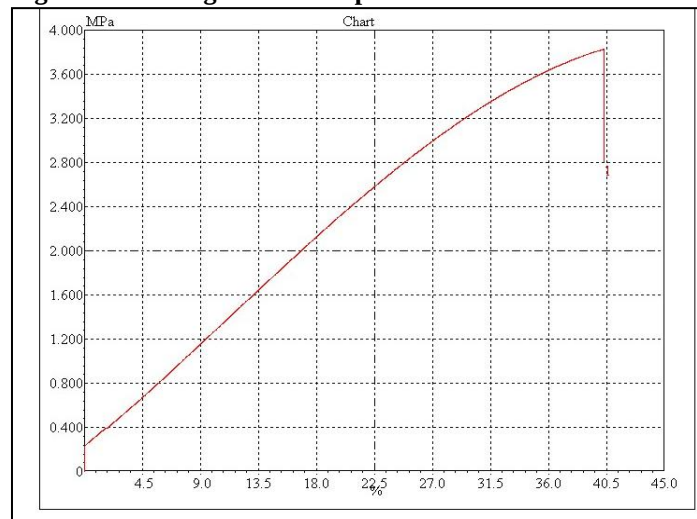


Figure 3: Bending test on Sample 3 of UPR treated with ABS

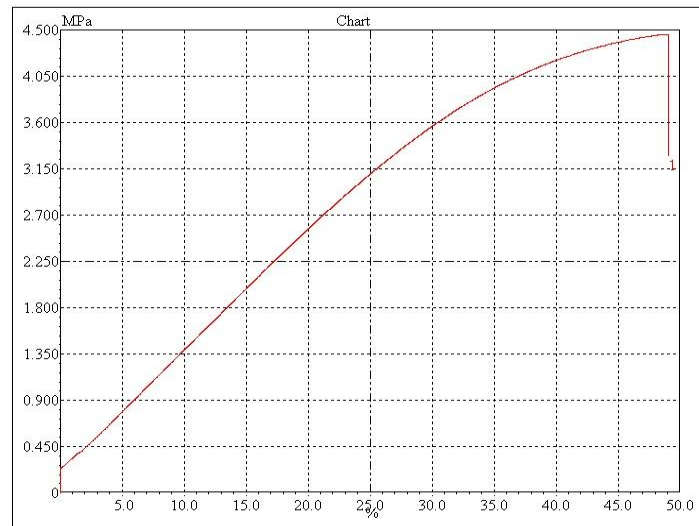


Figure 4: Bending test on Sample 4 of UPR treated with ABS

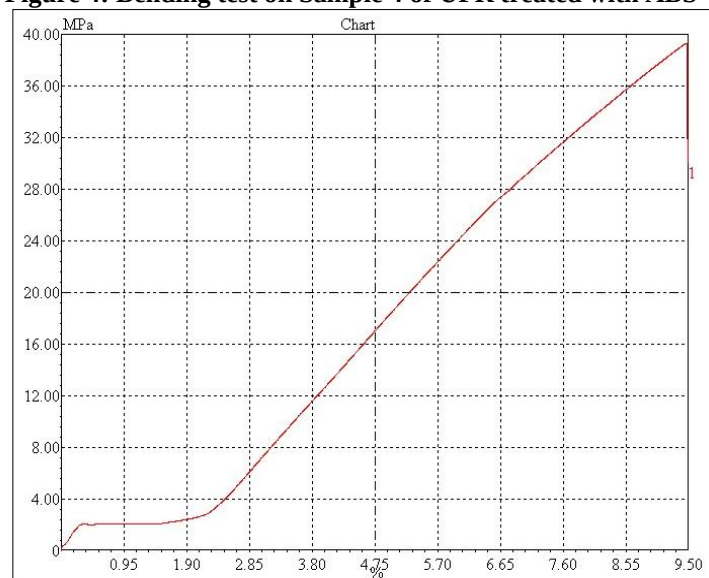


Figure 5: Bending test on Sample 1 of UPR treated with ABS

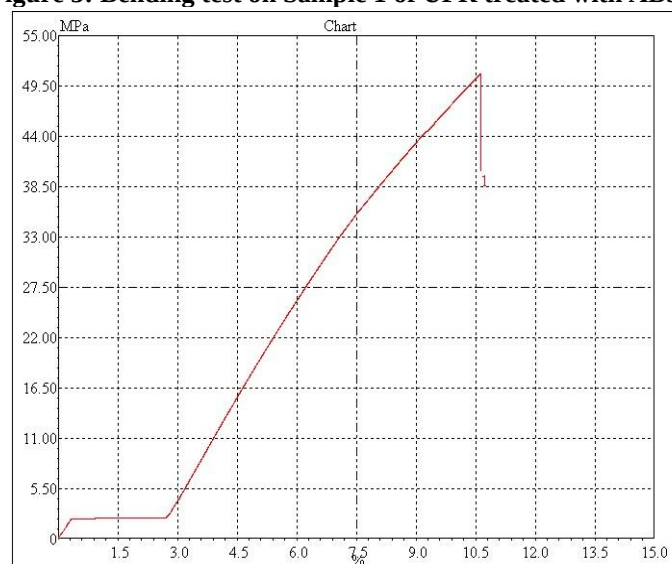


Figure 6: Bending test on sample 2 of UPR treated with ABS

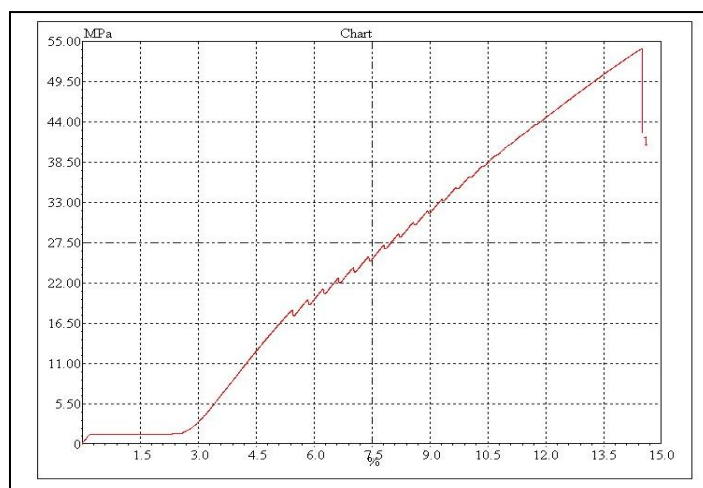


Figure 7: Bending test on Sample 3 of UP treated with ABS

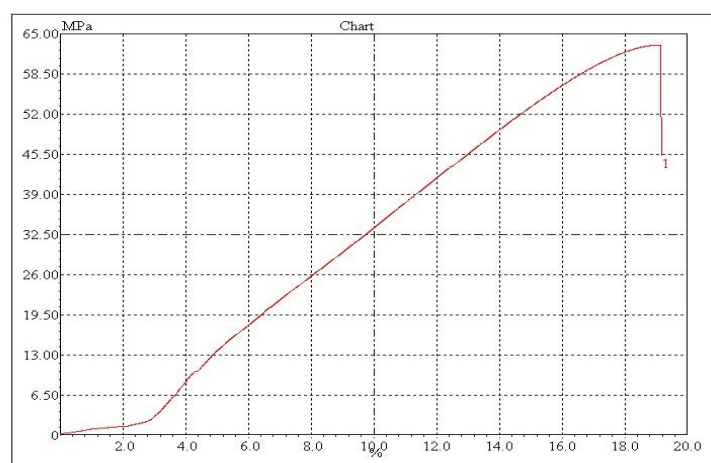


Figure 8: Bending test on Sample 4 of UPR treated with ABS

VI. The morphological investigation of UPR treated with ABS

In heating time and as soon as the mixture of UPR was prepared, because of a difference between the solution parameters, the formation of crosslink, resin polarities and finally its solution parameter will change.

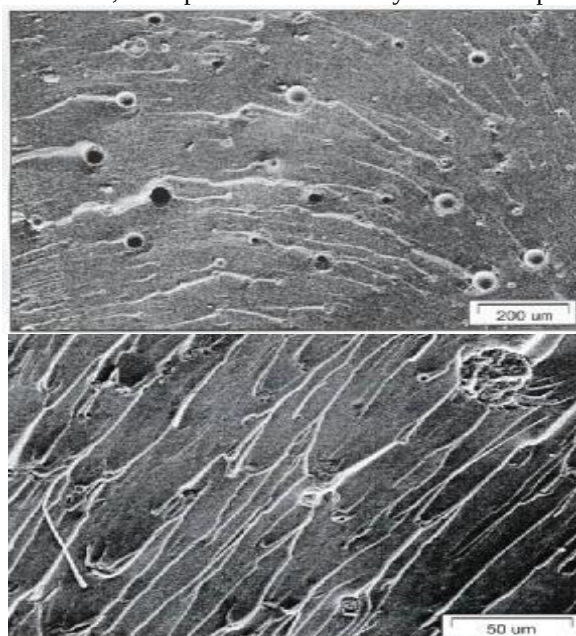


Figure 9: SEM observation of the surface of alloy fraction of UPR treated with ABS ;Magnified: $\times 3000$ – (a), $\times 5000$ - (b)

