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Decorative Articles Based on Polymeric Materials

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Abstract: The aim of the research is to create decorative articles based on polymeric materials, study the effects of fillers and the type of moulds that it can cope with the exothermic reaction nature of resin to create a scientific background on the usage of the resins in daily life products. The polymeric materials that will be concentrated on are the unsaturated polyester resins and epoxy resins. The unsaturated polyester is of many types and chemical constituents, the used experimentally is a general-purpose type and the epoxy also have different types and the used is a commercially 3D floor coating type. The resulted articles that were achieved in the research from unsaturated polyester resins are two tables with different dimensions, vase, candle, decorative articles and bricks. As for Epoxy, two different dimensions 3D tiles with artificial flower immersed within it.

Index : Terms: Decorative articles, Polymers.

I. INTRODUCTION

The polymers industry had expanded to be with a significant importance in daily usage products manufacturing. Thermosets polymers specifically, such as unsaturated polyester and epoxy are known for their significant mechanical and physical properties, which was the reason for their industrial widespread in the last years. Even though there production is increasing but there usage in the decorative fields are not well known to individuals that they can be done on small scale, with right mixing ratios, fillers and suitable moulds materials.

The aim of the research is to create decorative articles from polymeric materials such as unsaturated polyester and epoxy resins and to determine the suitable mould to work with. The decorative articles objectives are, to prepare tables, building blocks, vase, candles using unsaturated polyester and preparing decorative 3D tiles using epoxy resins. Also, modifying the mechanical and physical properties by the addition of fillers such as calcium carbonate ($CaCO_3$) and adding colorants to change the article appearance, and comparing both pure and modified material by applying mechanical test such as compression and tensile test.

The research will provide different advantages such as the suitable materials to work with resins, increasing and spreading the use of resin in decorative articles for individuals and not only of large scale as resins are easily used, and providing less cost production by the usage of fillers as the quantity of the polymer will be less.

The research is divided on different steps, first is to determine the amount of activator and initiator needed to reach the desired curing time for the polyester resin and choose the suitable type of polyester that are purchased from different distributors. Second is to determine the effect of CaCO3 as a filler that is added to the polyester by applying mechanical tests, such as tensile test and compression test. Third is the observation of variation in the original colours then when added to a pure polyester sample and a polyester sample with CaCO3 to determine the desired quantity of colour needed for the required article. Fourth is the utilization of different moulds materials such as, silicon, metal, carton box and tubular paperboard can with a foil-lined interior to distinguish between their behaviour with the reaction and to determine the most suitable material to be used. Unsaturated polyester prepolymers mixed with cross-linking monomers and catalysts. The resulting mixture is normally a viscous liquid that can be poured, sprayed, or shaped into the desired form and then transformed into a thermosetting solid by cross-linking. The unsaturated polyester prepolymers are obtained from the condensation of polyhydric alcohols and dibasic acids. The dibasic acid consists of one or more saturated acid and/or unsaturated acid. The saturated acid may be phthalic anhydride, adipic acid, or isophthalic acid, while the unsaturated acid is usually maleic anhydride or fumaric acid. The polyhydric alcohols in common use include glycol (such as ethylene glycol, propylene glycol, diethylene glyco

Table 1. Filler used ad their effect on Polyester [2]

Filler	Resulting feature
Calcium carbonate	Cost reduction
Clay	Surface enhancement
Alumina trihydrate	Fire retardant
Talc	Enhanced resistance to temperature
Mica	Enhanced weathering

Epoxy resins are complex network polyethers usually formed in a two-staged process. The first stage involves a base-catalyzed step-growth reaction of an excess epoxide, typically epichlorohydrin with a dihydroxy compound such as bisphenol A. This results in the formation of a low-molecular-weight prepolymer terminated on either side by an epoxide group. [3]

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In the second stage, a cross-linked network structure is formed by curing the prepolymer with active hydrogen-containing compounds. These curing agents include polyamines, polyacids and acid anhydrides, polyamides, and formaldehyde resins. Amines, preferably liquid amines like triethylene diamine, effect cure of the prepolymer by ring-opening of the terminal epoxide groups. [3]

II. EXPERIMENTAL WORK

The articles are prepared by measuring the volume of the mould to measure the mass of polyester needed and the mould is filled with petroleum jelly to ease the removal of the article after curing. Different mould was used for each article, such as polyurethane foam, carton box, tubular paperboard can with foil-lined mould, and silicon mould. Then cobalt octoate is added with 0.2 wt.% of polyester and mixed well, then followed by the addition of the $CaCO_3$ (25 wt.% or 50 wt.% of total mass), the colour and finally the initiator is added with 2 wt.% of the polyester. The volume of the mould is calculated to determine the mass of epoxy required. The metal box is covered with petroleum jelly. The epoxy is added with the hardener with a ratio of 3:1 by mass. The mixture is stirred very well, and then poured into the mould. The artificial flowers are immersed into it and the cast is left to be cured.

III. RESULTS AND DISCUSSION

Products with polyester were manufactured as follows.

Figure 1 Small Table

Where: dimensions are:

Length x Width x thickness= 33 x 29 x 2 = 1914 cm^3

Legs height= 50 cm each

Mass required for the mould $= \rho$ x volume

$1.11x\ 1914 = 2124.54$ g

Colour used: addition of $CaCO_3$ only gives the table colour.

Figure 2 Colored Table

- Dimensions:

Length x Width x thickness =
43 x 29 x 2 = 2494 cm^3
Legs height= 50 cm each

- Mass required for the mould $= \rho$ x volume

$1.11x\ 2494 = 2768.34$ g

- Colour used: Red

Figure 3 Colored Vase

- Dimensions:

Hollow Cylinder Part

$$\pi\ x\ h\ x\ (R^2 - r^2) =$$

$$\pi \text{ x } 20.7 \text{ x } (3.75^2 - 2.75^2) = 422.7 \text{ cm}^3$$

Cylinder part (base)

$$\pi\ x\ h\ x\ (R^2) =$$

$$\pi \text{ x } 1.5 \text{x } (3.75^2) = 66.27 \text{ cm}^3$$

Total volume = 422.7 + 66.27 = 488.9 cm^3

- Mass required for the mould $= \rho$ x volume

$1.11x\ 488.9 = 542.7$ g

- Colour used: Pink

Figure 4 Decorative Flowers

- Dimensions:

The mould shape is undefined, so it is filled with water to determine the volume of the mould and the volume is multiplied by the density of polyester to determine the required mass.

Volume= 66 ml =66 cm^3

- Mass required for the mould $= \rho$ x volume

$1.11x\ 66 = 73.26$ g

- Colours used:

Blue

$CaCO_3$ only with pink colour at the bottom

Figure 5 Decorative Candle

- Dimensions:

Hollow Cylinder Part
$\pi \times h \times (R^2 - r^2)$ =
π x 20.7 x (3.75^2 -2.75^2) = 422.7 cm^3
Cylinder part (base)
$\pi \times h \times (R^2)$ =
π x 1.5x (3.75^2) = 66.27 cm^3
Total volume = 422.7 + 66.27 = 488.9 cm^3

- Mass required for the mould = ρ x volume

1.11x 488.9 = 542.7 g

- Colour used: Pink

Figure 6 Bricks

- Dimensions

Length x Width x thickness=
14.5 x 8.5 x 4 = 493 cm^3

- Mass required for the mould = ρ x volume

1.11x 493 = 547.23 g

- Colour used: Red

Products with epoxy were manufactured as follows.

Figure 7 Rectangular Shape Tile

- Dimensions

Length x width x thickness =
25.8 x 16.7 x 1.5 = 646.29 cm^3

- Mass required for the mould = ρ x volume

1.17 x 646.29 = 756.16 g

Figure 7 Square Shape Tile

- Dimensions

Length x width x thickness =
25.8 x 16.7 x 1.5 = 646.29 cm^3

- Mass required for the mould = ρ x volume

1.17 x 646.29 = 756.16 g

IV. CONCLUSION

The research took several stages. First to study the curing time of the polyester resin, the percent of the activator and initiator and choosing the best polyester type to work with, the curing time range was from 15 minutes to 25 minutes and the activator weight percent ranges from 0.2 to 0.4 and the initiator 2 to 2.5 weight percent. As for epoxy, the mixing ratio is 3:1 epoxy to hardener and it is fixed, and its transparent colour is required for the desired articles, so no further experiments were done on it. The effect of $CaCO_3$ as a filler on polyester was then studied through mechanical tests and it achieved the hypothesis, as the sample filled with $CaCO_3$ showed better resistance to load in tensile and compression tests. Followed by, choosing the colour stage and controlling the quantity to obtain the desired end-product appearance, also the colours of a pure polyester and polyester filled with $CaCO_3$ samples were compared. The articles were done in different moulds to study and determine the effect of the reaction on each type of mould, the worst mould is the polyurethane foam as it was swollen by the polyester and the best moulds were the metal and silicon moulds. The products (articles) that were obtained from the polyester were, two tables with different dimensions, vase, candle, decorative flowers and building blocks. As for the epoxy, the products were two different dimensions 3D tiles with artificial flower immersed within it.

This work resulted eight articles done with polyester and epoxy. In order to improve and enhance this work further work can be done, such as applying the work on large scale using silicon mould as it is the best to work with. Also, to examine different fillers to improve the mechanical tests more and to apply cost analysis and determine its economic value.

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