THE ROLE OF FIBER GLASS IN RETARDING THE FLAMMABILITY OF EPOXY RESIN[+]

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Abstract

In this investigation , the role of fiber glass in retarding the flammability of epoxy resin is studied. The test samples were prepared according to (ASTM:D-2863) American Standard Testing method. These samples were tested by using apparatus of (LOI) limiting oxygen index. Also the standard test method of Rate of Burning, Extent of Burning and Time of Burning for self-supporting specimens were used, according to (ASTM:D-635).

المستخلص

تمت دراسة دور الالياف الزجاجية في تثبيط لهوبية الابوكسي، جهزت النماذج وفقا" لطريقة القياس الأمريكية (ASTM:D-2863) وفحصت هذه النماذج باستخدام جهاز(Limiting Oxygen Index(LOI)) كما تم الفحص باستخدام طريقة قياس معدل سرعة الاحتراق وزمن الإحراق ومداه لعينات محمولة أفقيا، وفقاً لطريقة القياس الأمريكية(ASTM:D-635) .

Introduction

Recently, many reports on the study of flame retardancy of polymeric materials have tackled the role of additives in inhibiting the flammability of polymers. This work studies the flame retarding for fiberglass as well as its role in reinforcement to numerous materials.

Typically , flame retardant depend on the compatibility with matrix (materials substrate) as well as depends on their chemical structure. Different polymers have different tendencies to react with oxygen at elevated temperatures prior to ignition [1].

1- Flame retardation in Epoxy resin

There is extensive literature describing the effect of a wide variety of phosphorus , halogenated compounds and metallic oxides in flame retardation of epoxy resin [1]. The epoxy resin system is not different from other polymers [2].

The phosphorus and halogenated compounds both impart flame retardant to epoxy resins. Approximately 5 – 6% weight percent of phosphorus is required to attain significant flame retardation.

[+] **Received on 29/10/2004 , Accepted on 9/3/2005**

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Most of phosphorus – halogen compositions containing about 2% phosphorus and 6% Chlorine produce self – extinguishing epoxy resin [2] .. Antimony oxide , like phosphorus compounds reduces the flammability of resin composition .There is synergistic action between antimony oxide and halogenated – compounds to retard the flammability of plastics.

With regard to halogen – compounds , fluorine is relatively ineffective. But the chlorine is less effective than bromine , 30% chlorine is required to produce the same relative level of retardation as 15% bromine [2].

Finally , boron , boric acid , sodium and calcium borate produce self – extinguish at certain percentage weight. [1]

2- Fiber glass

By variation of the "recipe" different types of glass can be produced: The types used for different purposes are as follows:

(A) E-glass(electrical)-lower alkali content. With good tensile and compressive strength and stiffness, good electrical properties and relatively low cost. E-glass is the most common form of reinforcing fiber used in polymer matrix composites.

(B) C-glass (chemical)- best resistance to chemical attack. It is mainly used in the form of surface tissue in the outer layer of laminates used in chemical and water pipes and tanks .

R,S and T-glass- are manufacturers' trade names for equivalent fibers having higher tensile strength and modulus than E-glass with better wet strength retention .[3]

3- Epoxy resin

This resin system will productce a low viscosity, semi-clear, low odor epoxy that is not only ideal for layup use, but also as a sealer of porous substrates such as wood because of its penetrating power.

Epoxy Resin System is our most popular for lamination with fiberglass, carbon fiber, or any type of reinforcement. It generates fast wet-out and easy application of any reinforcement.The choice of hardener is based on specific temperature, curing thickness, desired working time and desired drying-times.[3]

4-Historical review

In (1927) ,light weight Epoxy resin was discovered by Schrade.[3].

Perkin (1930) was a first man who proposed the using of metallic oxides as flame retardant [4].

In (1947) Arthur and Bowring had studied the effect of volatile additives to the oxidizing atmosphere surrounding electrode carbons at temperature of 85 C the CO/CO2 ratio was used a measure of the effectiveness of the additives. [5]

In (1970) lyons studied the effectiveness of phosphorus compounds as tixe retardants phosphorus compounds decomposes to acid fragments under the influence of heat [6].

In (1989) Epoxy resin was prepared by A.A. jabber in basrah university[7].
In (2000), H. I. Jafer studied the fiber glass as reinforcement for some polymers[8].

Experimental

1- Materials

Epoxy resin with trade name of (635) is a thin resin with one type hardner. Fiber glass (E-fiber glass type) was supplied by United Arab Emaret (U.A.E.). (AL-jazeera Company for Scientific Equipment)

2- Apparatus of (LOI) Limiting Of Oxygen Index

The apparatus used is locally built in Materials Laboratory, Physics Department , College of Science-University of Baghdad, it is shown in Fig (1).

3- Flowmeter

Two types of flowmeters were used " F M 112 – 025 T " and "FMO 92 – 045 T" each of them is a glass tube type graduated to (150mm) containing a stainless steel spherical float equipped with needle valve control. Maximum flow rate at laboratory conditions was approximately (832 ml/min) for FM 112 – 025 T and (407 ml/min) for "FM 092 – 045 T".

4- Timer

It is a timing device, stop – watch, which is shown in Fig (1) .

5- Gas sources used, are oxygen and nitrogen bottles , The gases were with purity of 99.95%

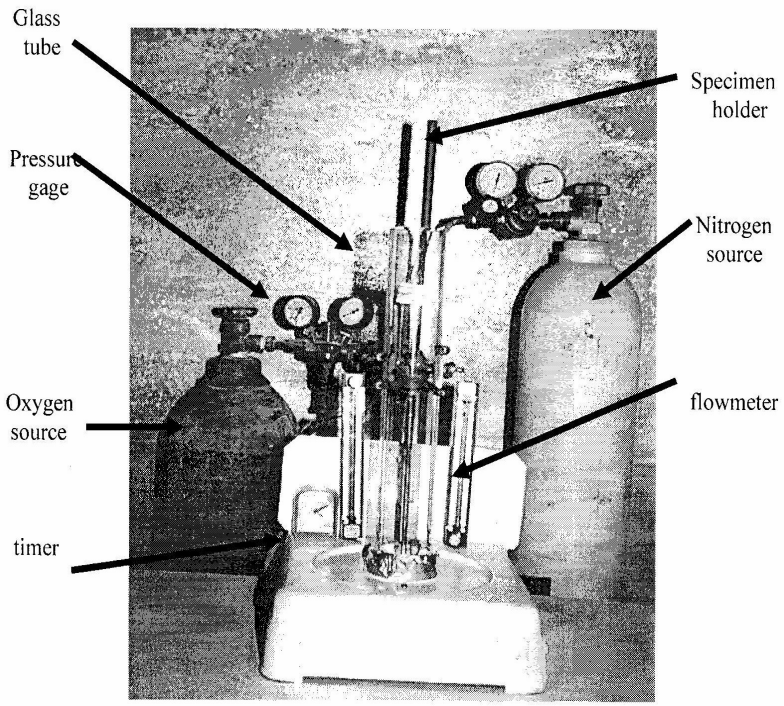

Fig. (1): Apparatus of limiting Oxygen index according ASTM: D-2863

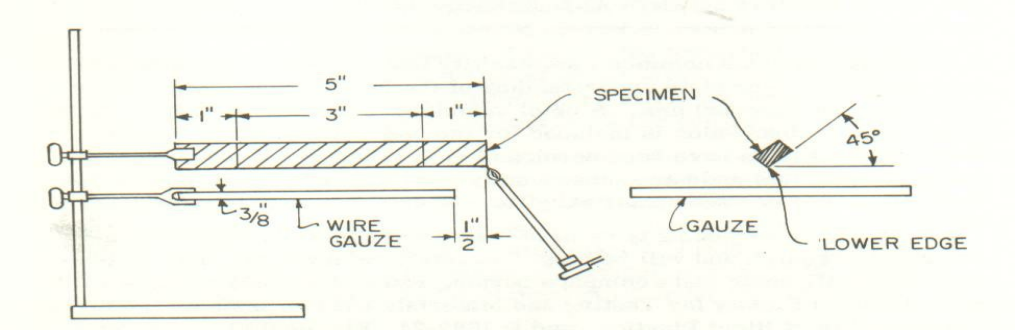

Fig (2): Standard Test Method according to ASTM:D 635

6- Burner (ignition source)

Benzene flame or propane or other gas flame.

7- Procedure

Sheet preparation

Epoxy sheet were prepared as follows

1- Epoxy (Base) 10 , and amino acid (hardener) were mixed in (3:1) weight.And they were poured in glass mold of the dimensions of 150mm length,150 mm width and 3 mm thickness.
2- One layer was added to epoxy mixture weight(epoxy + hardener) to prepare a sheet with one layer .
3- Two layers were added to epoxy mixture weight (epoxy + hardener)) to prepare a sheet with two layers .
4- Three layers were added to epoxy mixture weight (epoxy + hardener) to prepare a sheet with three layers .
5- Sheets were left to be hard.

8- Test specimens

The specimens were cut in dimension of 125 ± 0.5 mm in Length, 125 ± 0.5 mm in width and thickness of 3 mm.

Each test specimen was marked by scribing two lines, in location of (125mm) and (100 mm) from one end of the specimen.

Results and discussion

In this work , limiting oxygen index (LOI) which has been used . according to (ASTM : D – 2863) was (18.3) when one layer of random fiber glass of epoxy resin was used. And it was increased to (19.5) when two layers of random fiber glass were added to epoxy resin. Then limiting oxygen index became 21.2 when three layers were added.

But with regard to 090 type of fiber glass, the (LOI) , took the values (18.2) , (19) and (21.3) when one , two and three layer of 090 types of fiber glass were added respectively as shown in table (1).

Table (1) illustrates that the limiting oxygen index (LOI) of pure epoxy was less than LOI of one layer in both types of fiberglass because the thickness of epoxy covered the fiberglass was less than the thickness of pure epoxy.

Hence, the heat required for ignition of actual length of pure specimen must be more than the heat required in epoxy with one layer of fiberglass of both types (090 types and random type). The values of rate of burning and average time of burning shown in table (2) .The results indicate that the rate of burning decreases with increasing of layers.Finally, the average time of burning increases with increasing of layers.

Table (1): Results of limiting oxygen index for both types of fiberglass with epoxy

Specimens type	One layer	Two layers	Three layers	Pure
090 fiberglass layers and epoxy.	18.2	19	21.3	18
10. Random fiber glass layers and epoxy	18.3	19.5	21.2	18

Table (2): Results of Rate burning (R.B) and Average time of burning (ATB) and average extent of burning (AEB) to two types of fiber glass reinforcement as flame retardant

Specimens type		One layer	Two layers	Three layers	Pure
090 fiber glass layers and epoxy	AEB inch	4	4	4	4
	ATB Min	2.386	3.256	2.392	2.836
	R.B inch/min	1.257	0 – 921	0.50	1.057
10. Random fiber glass layers epoxy	AEB inch	4	4	4	4
	ATB Min	1.374	2.571	3.547	2.836
	R.B inch/min	2.183	1.166	0.845	1.05

Conclusions

1-Fiberglass has good efficiency in retarding the flammability of Epoxy resin, compared with other flame retardant that are used in other investigations.
2-Two standard methods are used, are first (LOI) limiting oxygen index according to ASTM:D–2863 , and Second rate of burning method according to ASTM:D-635.
3-The R.B "Rate of Burning" decreases with increasing of number of layers.
4-The ATB "Average Time of Burning" increases with increasing of number of layers.
5-The (LOI) limiting oxygen index increases with increasing of number of layers.

Appendix Table: Abbreviation and Symbols

Symbol	Expression
ASTM	American Standard Testing Measurement.
R.B	Rate of burning.
AEB	Average of extent of burning.
ATB	Average time of burning.
(0,90)	Represent the direction of fiberglass

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