EXPERIMENTAL INVESTIGATION IN ZINC BORATE EFFECT ON FLAMMABILITY CHARACTERISTICS OF POLYMERIC COMPOSITE MATERIAL

Ali I. Al-Mosawi
Technical Institute-Babylon,
IRAQ.
aliibrahim76@yahoo.com

Abbas A. Sakhir
Al- Qadisiya University,
IRAQ.
Doctor_abbas2001@yahoo.com

Mushtaq T. Albdiry
University of Southern
Queensland, AUSTRALIA.
mushtaqalbdiry@yahoo.com

Tareq Majeed
Babylon governorate,
IRAQ.

ABSTRACT

The main aim of this paper is to investigate flammability enhancement of araldite composite material reinforced by kevlar-carbon fibers by addition of a surface coating layer (4mm) thick from zinc borate. This system was exposed to a direct flame generated from oxyacetylene flame and gas flame under different exposure intervals (10,15, and 20mm), and study the range of resistance of flame retardant material layer to the flames and protected the substrate where we used the method of measuring the surface temperature opposite to the flame where we obtained the better results with large exposed interval and large percentage from protective layer which is zinc borate (30%) for both types of flames , as well as the flame resistance will be increased with decrease the flame temperature .

Keywords: Hybrid Composite Material, Flame Retardant Material, Zinc Borate.

INTRODUCTION

Fire safety is an integral part of precautions. Fire precautions have the objective to minimize the number of and damage from measuring hindering their initiation, limiting their propagation and if possible excluding flash-over. Preventing fires or delaying them makes escape possible over a longer period of time. As a result, life, health, and property are efficiently protected (Troitzsch, 1998). Since plastics are synthetic organic materials with carbon and often high hydrogen contents, they are combustible. For various applications in the building, electrical, transportation, mining, and other industries, plastics have to fulfill flame retardancy requirements laid down in mandatory regulation and voluntary specification. The objective in flame retarding polymers is to increase ignition resistance and reduce rate of flame spread (Al-Maamori *et al.*, 2011).

One way to better protect combustible materials against initiating fires is the use of flame retardants , which are substances that can be chemically inserted into the polymer molecule or be physically blended in polymers after polymerization to suppress , reduce , delay or modify the propagation of a flame through a plastic materials. There are several classes of flame retardants; halogenated hydrocarbons (chlorine and bromine containing compounds and reactive flame retardants): inorganic flame retardants (boron compounds, antimony oxides, aluminum hydroxide, etc.); phosphorus containing compounds; nitrogen containing flame retardants (Al-Jeebory *et al.,* 2008).

FLAME RETARDANT MATERIALS

Flame retardants are substances used in plastics, textiles, electronic circuitry and other materials to prevent fires. There are several types of flame retardants as mentioned above, one of these types is inorganic flame retardants. Few inorganic compounds are suitable for use as flame retardants in plastics, since such compounds must be effective in the range of decomposition temperature of the plastic, mainly (150ºC - 400ºC). Inorganic flame retardants don't evaporate under the influence of heat ; rather they decompose ; giving off non-flammable gases like water , carbon dioxide , sulphur dioxide , hydrogen chloride , etc. mostly endothermic reaction. In the gas phase, these act by diluting the

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mixture of flammable gases and by shielding the surface of the polymer against oxygen attack (Moslem, 2003).

The inorganic flame retardants act simultaneously on the surface of the solid phase by cooling the polymer via endothermic breakdown process and reducing the formation of pyrolysis products. In addition , as in the case of inorganic boron compounds , a glassy protective layer can form on the substrate , fending off the effect of oxygen and heat (Mouritz, Gibson, 2006) .As example to inorganic flame retardants is zinc borate , aluminum hydroxide , magnesium hydroxide , and antimony oxides . Zinc borate is used as a flame retardant and smoke suppressant for wide range of plastics, rubber, paper, and textiles. It can replace antimony oxide as synergist in plastics and rubber to enhance the activity of primary flame retardants by stepwise releasing the radicals in a wide variety of end – use products. It is also used in paints, adhesives, pigments and ceramic industries (Hatakeyama, 2005).

Experimental Work

a. Flame retardant material, Zinc Borate 2335 (2ZnO.3B2O3.5H2O) was used as a flame retardant, which supply from C-Tech corporation. Table .1 shows the chemical composition of zinc borate.

Table 1. Chemical composition of zinc borate

Compound	Zinc Oxide	Boric Anhydride	Water of Hydration	Impurities
Symbol	ZnO	B2O3	H2O	-
Content (%)	37	47	14	2

b. Composite material: consist of Araldite resin (CY223) with density of (1.15g/cm^3) ,and Kevlar - Carbon fibers, A woven roving fibers(0º - 90º) .

Preparation Test Samples

Samples of thermal erosion test are a square shape, as shown in Fig.1 with dimensions (100 ×100mm), and (10mm) thickness, which it consists of two layers: Flame retardant material layer with (4mm) thickness represented by zinc borate, and Composite material layer with (6mm) thickness, it contains carbon and kevlar fibers which used as consecutive layers in araldite resin.

Flame Retardancy Test

Two types of torch flame were used, oxy-acetylene with 3000 ºC and butane-propane flame with 2000 ºC. The system (contains flame retardant material and composite material) was exposed to these flames under different exposure intervals (10, 15, and 20mm). Surface temperature method used here to calculate the amount of heat transmitted through flame retardant material and composite material. A transformation card (AD) which called thermal monitoring and recording system(see Fig.1) was used to observed and saved temperatures with time (in seconds) .

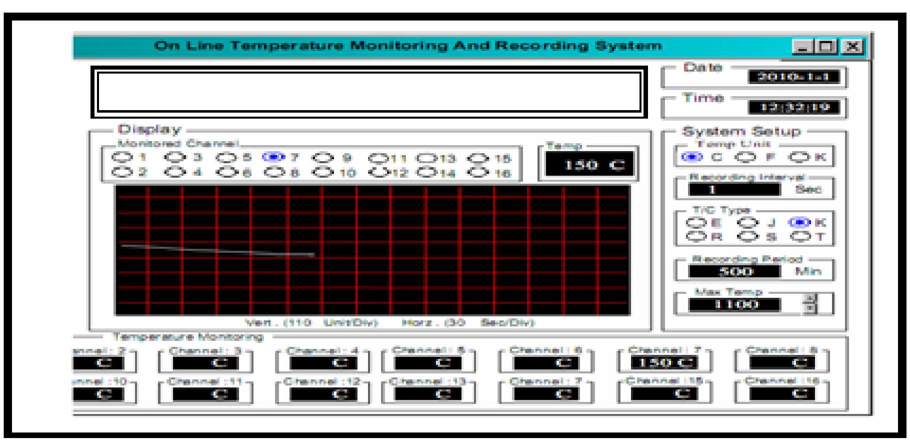

Figure 1. Thermal monitoring and recording system

RESULTS AND DISCUSSION

Figure 2 represents the flame retardancy test for composite material with zinc borate as a surface layer at exposed interval (10mm), the temperature of the opposite surface to the torch begins to increase with increasing the time of exposition to the flame. During this stage , zinc borate (10 %) has a water of hydration in its chemical structure , therefore , it released this water to extinguish the fire through cooling , in addition , zinc borate will formed glassy coating layer which protecting the substrate (composite material) and the fire spread will decrease (Formicola *et al.,* 2009) . This process of released water and formation of glassy coating layer will be increased as the zinc borate increased to (20 %, 30 %).

Figure 3 shows the behavior of zinc borate with exposed interval (15mm). When the amount of flame retardant layer is (10 %), and with this exposed interval the time of breakdown of the retardant layer will be increased, because of decomposition of zinc borate and release the water, which dilute the ignition zone and the formation of protected layer will stay to longer time, and this state will be increased with increasing zinc borate content to (20 %, and 30 %) (Al-Jeebory *et al.,* 2008)

As a result, when the exposed interval to flame increased to (20mm), the time necessary to break down of flame retardant layer will increase and the combustion gaseous will reduced and there will be a less plastic to burn due to water of hydration and protected glassy coating layer, and this protection will improves with increasing flame retardant percentage to (20 %, and 30 %) (Al-Mosawi *et al.,* 2012). All that will rise the time of break down for zinc borate layer and substrate composite material as shown in Fig.4 which represents flame retardancy test for zinc borate layer with exposed interval (20mm) .The optimum results were with large exposed interval and large percentage from protective layer which is zinc borate (30%) for both types of flames , as well as the flame resistance will increase with decrease the flame temperature as illustrated in the diagrams between surface temperature and time of flame exposition.

CONCLUSIONS

From this study, we concluded that: Increasing the flame retardancy as the zinc borate content increased. The resistance to flame spread will increased with increasing of exposed interval, due to decreased of the heat transmitted to flame retardant material which will rise the stand of glassy coating layer against flame. The flame retardancy is increased as the flame temperature is decreased.

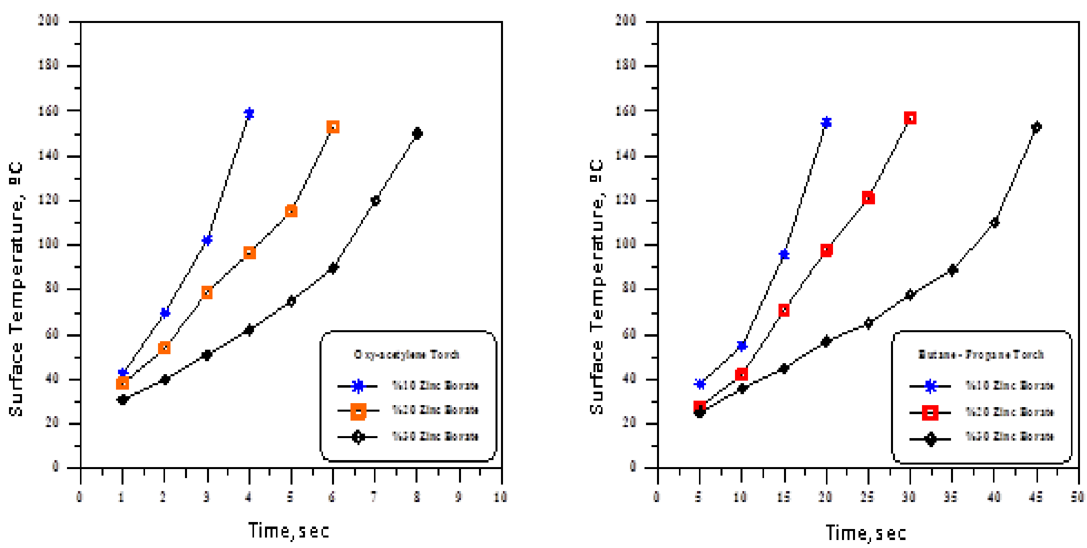

Figure 2. Flame retardancy results for zinc borate layer with exposed interval (10mm)

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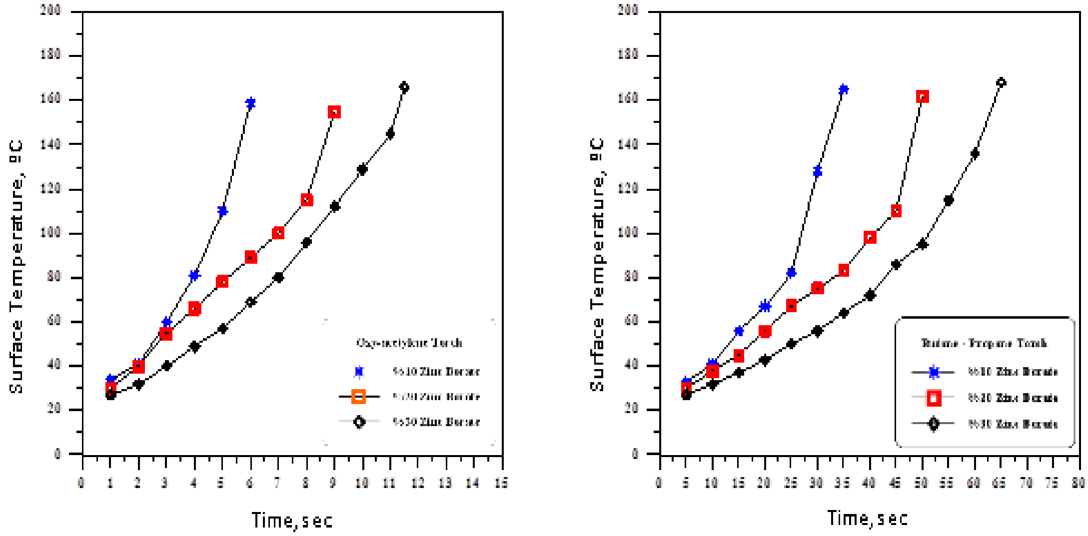

Figure 3. Flame retardancy results for zinc borate layer with exposed interval (15mm)

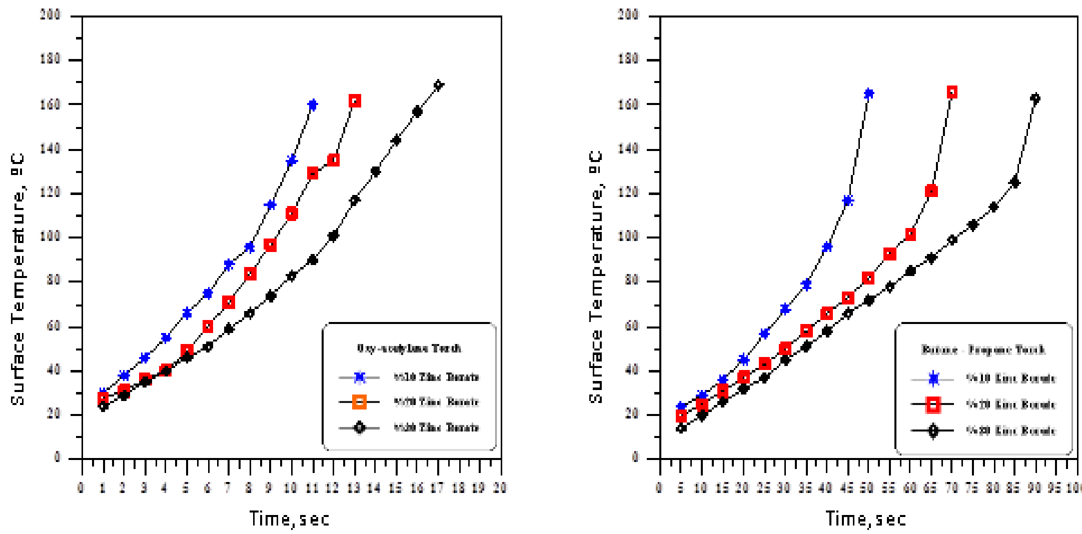

Figure 4. Flame retardancy results for zinc borate layer with exposed interval (20mm)

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