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IMPROVEMENT OF FLAME RETARDANCY FOR HYBRID COMPOSITE MATERIAL BY USING ZINC BORATE

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Abstract :

Zinc borate was added as a surface layer of (4mm) thickness on the surface of araldite resin reinforced by woven roving carbon-kevlar fibers .This system was exposed under different exposure intervals (10,15, and 20mm) to a direct flame which generated from oxyacetylene and gas flame (3000ºC,2000ºC) respectively, and study the range of resistance of flame retardant material layer to the flames and protected the substrate . Surface temperature opposite to the flame method was used to measuring the temperature transferred through this system. The experimental results show that a great increment in thermal resistance and flame retardancy after coating by zinc borate and the best percentage was (20%) from zinc borate, as well as rising flame resistance increased exposure intervals to flame .

Keywords:Zinc borate ,Flame retardancy , Composite material .

تحسين إعاقة اللّهب لمادة متراكبة هجينة بإستعمال بورات الزنك

الخلاصة:

تم إضافة بورات الزنك بشكل طبقة سطحية بسمك (4mm) على سطح راتنج الإرلدايت المقوى بألياف كاربون- كيفلار المحاكة. تم تعريض هذا النظام وبمسافات تعرض مختلفة (20mm,15,10) إلى لّهب مباشر متولد من شُعلة أُوكسي أستلينية وشُعلة غازية بدرجة حرارة (2000ºC, 3000ºC) على التوالي ، ودراسة مدى مقاومة طبقة المادة المعيقة للّهب لحرارة الشُعلتين ومدى حمايتها للمادة المتراكبة الواقعة تحتها . تم إعتماد طريقة قياس درجة حرارة السطح المقابل للشعلة في قياس درجة الحرارة المنتقلة خلال هذا النظام . أظهرت نتائج الإختبارات العملية زيادة كبيرة في المقاومة الحرارية وإعاقة اللّهب للمادة المتراكبة بعد طلائها ببورات الزنك وأفضل زيادة كانت عند نسبة (20%) من بورات الزنك ، إضافة إلى إرتفاع مقاومة اللّهب مع زيادة مسافة التعرض للشُعلة الحرارية .

الكلمات الدالة : بورات الزنك ،إعاقة اللّهب ، مادة متراكبة .

INTRODUCTION :

Flame retardants are chemicals which are added to many materials to increase their fire safety. For example, many plastics are highly flammable and therefore their fire resistance is increased by adding flame retardants in order to reduce the risk of fire. Flame retardants work through a number of different mechanisms. The ultimate goal is to decrease the potential of ignition or to delay the spread of a flame over the body of material the retardant is protecting. This is accomplished by increasing the combusting resistance of the materials to continue burning [Levchik,2007]. Flame retardants are applied in a number of different methods. They can be impregnated into plastics during processing, blended with insulation materials during application, used as treatments on shingles and decks and applied on the surface of materials as coatings or paints [Troitzsch,1998]. Some flame retardants cause a treated material to char thus inhibiting the pyrolysis process. Others remove flammable gases by reacting with the hydrogen and hydroxide radicals in the air. There are four primary substances which work to retard fire in different ways. These families include halogenated, phosphorus, nitrogen and inorganic flame retardants [Keshan etal,2006]. Zinc borate which belongs to inorganic flame retardants 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 [Heinrich,Stefan,2000]. It is also used in paints, adhesives, pigments and ceramic industries [Ali,2003].

[Ali,2011] was used an inorganic fire retardant which represent zinc borate to increase the flame retardancy for advanced composite material consist of araldite resin (AY103) reinforced by hybrid fibers from carbon and Kevlar fibers .[Abbas etal,2008]This was investigated possibility to increase the flame retardancy for composite materials by addition of a flame retardant material which represent the zinc borate as a coating layer of (4mm) thickness on the surface of composite material consist of araldite resin reinforced by hybrid fibers from carbon and kevlar fibers as a consecutive layers . [Ali etal,2010]was studied the compilation between two types of inorganic flame retardants zinc borate and antimony trioxide and study the effect of this compilation on thermal resistance at elevated temperatures for advanced composite material consist from unsaturated polyester resin and glass fibers, where the thermal erosion test at (2000°C) and (3000°C) .[Mostashari,2007] was studied comparative effect of selected hydroxides of groups IA and IIA on the flammability of a cotton fabric .

EXPERIMENTAL WORK :

1- Materials: There are three types of materials employed in this study:

a.Zinc Borate 2335 ($2ZnO.3B_2O_3.5H_2O$) was used as a flame retardant with contents (10%,20%). Zinc borate was supplied from C-Tech corporation with chemical composition shown in **Table.1** .

b. Araldite resin (CY223). with (1.15 g/cm^3) density .

c. Reinforcing fibers: Carbon- Kevlar fibers, as woven roving (0º-90º) fibers with surface density (225 g/m^2) and (285 g/m^2) respectively .

2- Preparation test samples.

Sample of thermal erosion test has a square shape, as shown in **Fig .1** (100 ×100×10mm) dimensions which it consist of two layers: Flame retardant material layer with (4mm) thickness ,and Composite material layer with (6mm) thickness

3- Thermal erosion test .

Oxyacetylene and butane-propane flame were used under different exposure intervals (10, 15, and 20mm). A transformation card (AD) which called Thermal monitoring and recording system **Fig .2** was used to observed and saved temperatures with time (in seconds) .

RESULTS AND DISCUSSION :

Fig .3 represents the thermal erosion 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 [Ali,2011] . This process of released water and formation of glassy coating layer will be increased as the zinc borate increased to (20 %).

Fig .4 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 break down 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[Heinrich,Stefan,2000]. This state will be increased with increasing zinc borate content to (20%). 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[Ali,2003], and this protection will improves with increasing flame retardant percentage to (20%). All that will rise the time of break down for zinc borate layer and substrate composite material as shown in **Fig .5** which represents flame retardancy test for zinc borate layer with exposed interval(20mm) . The better results was (20%) from zinc borate for both types of flames .

CONCLUSIONS :

From this study, we concluded that:

1- Using zinc borate improved the flame retardancy of composite.

2- The optimum improving in flame retardancy was with zinc borate content (20%) and exposed interval 20 mm.

Table .1 : Chemical composition of zinc borate

Compound	ZnO	B_2O_3	H_2O	Impurities
Content(%)	37	47	14	2

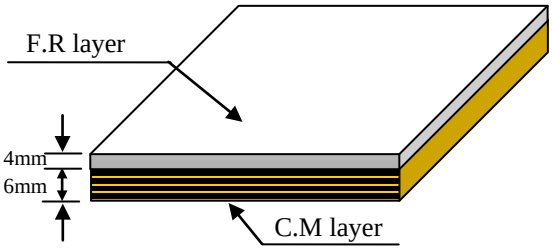

Fig .1 : Sample of thermal erosion test

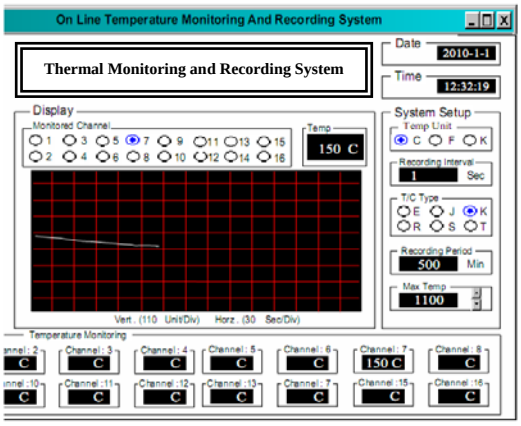

Fig .2 :Thermal monitoring & recording

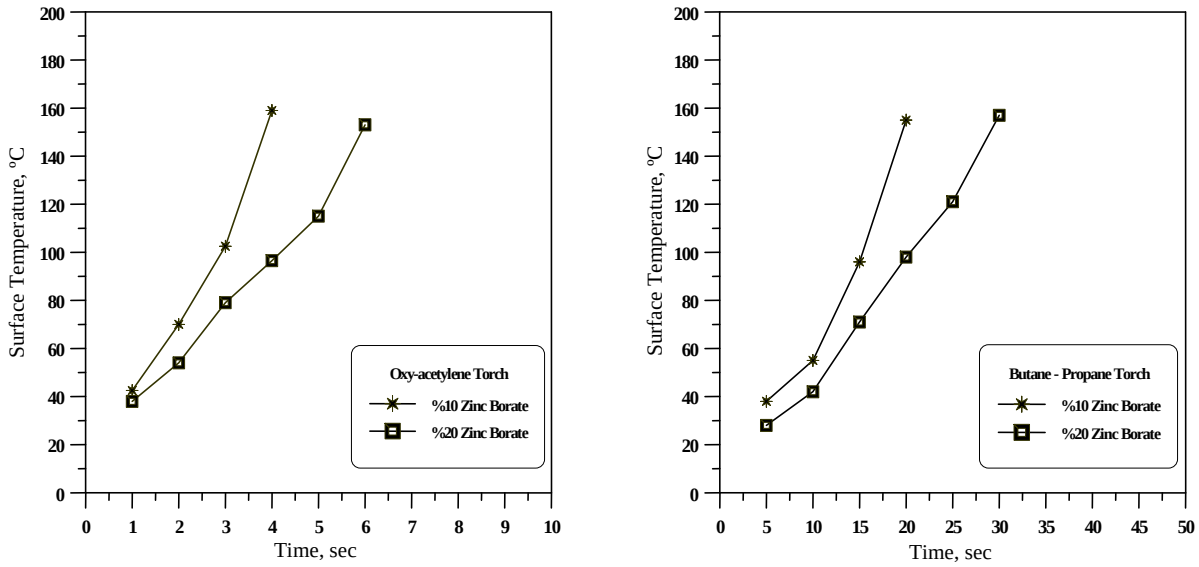

Fig .3 : Flame retardancy results for zinc borate layer with exposed interval (10mm)

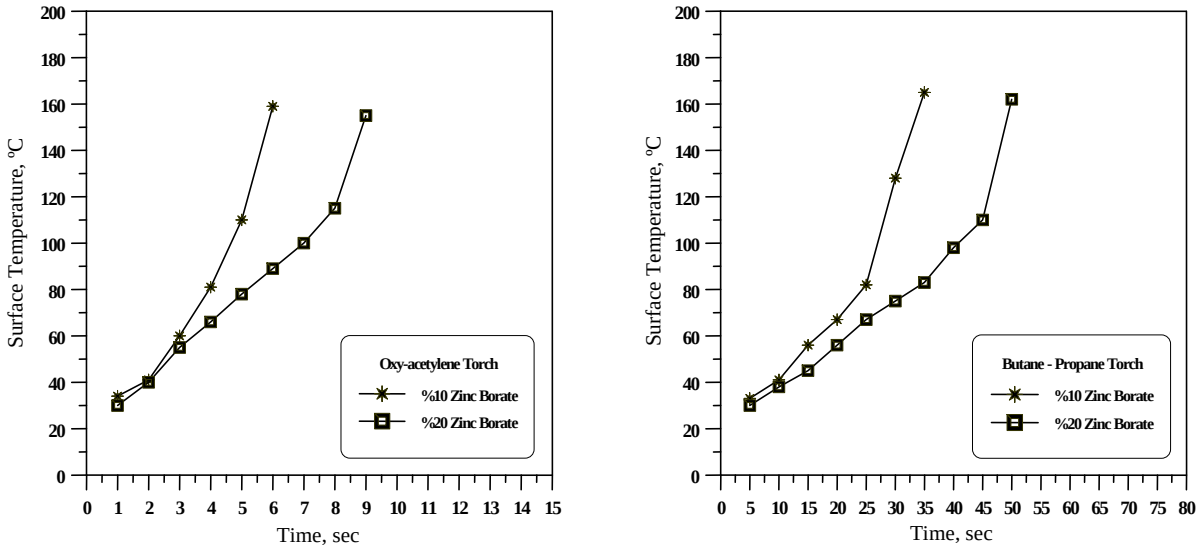

Fig .4 : Flame retardancy results for zinc borate layer with exposed interval (15mm)

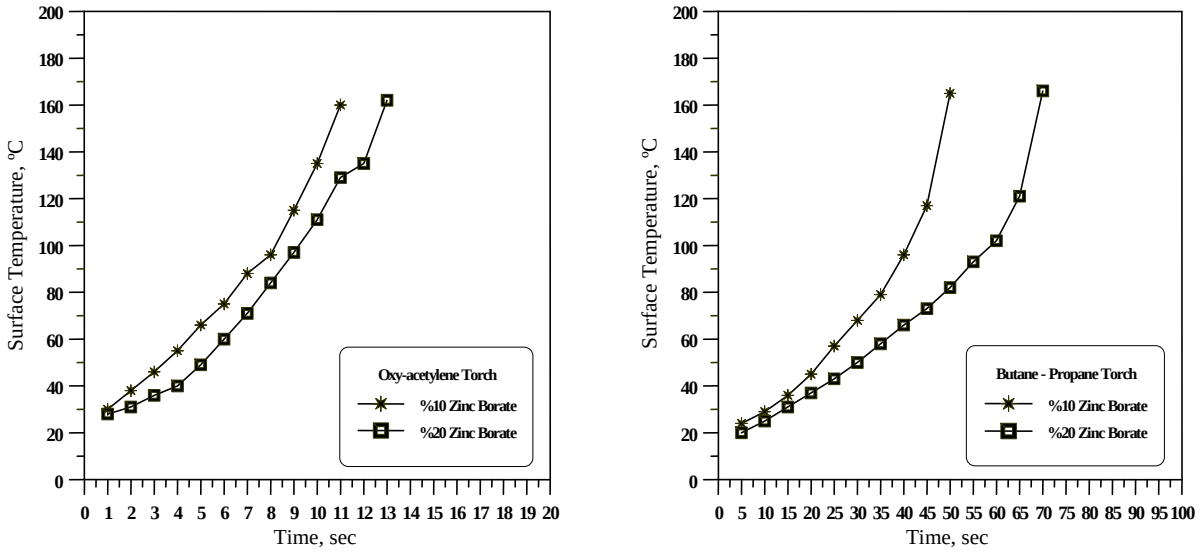

Fig .5 : Flame retardancy results for zinc borate layer with exposed interval (20mm)

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