# Fire retardancy characteristics of polymeric composite materials

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## Abstract:

Fire retardancy characteristics of polymeric composite material reinforced by fibers using coating by a fire retardant layer represent antimony tetroxide was studied. A coating layer (4mm) thickness from antimony tetroxide was used as a surface layer to react and prevent spread of flame on surface of epoxy resin reinforced by carbon – Kevlar fibers and exposed this coating layer to direct flame generated from oxyacetylene flame with different exposure distances (10,15,20mm) and study how it can protect the substrate . The experimental results showed that a great increment in thermal resistance and flame retardancy after coating by antimony tetroxide as well as rising flame resistance increased exposure distances to flame.

**Keywords: Fire Retardancy, Composite Material, Inorganic retardants.**

## Introduction:

The objective in flame retarding polymers is to increase ignition resistance and reduce rate of flame spread. 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 [1]. 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. Some flame retardants cause a treated material to char thus inhibiting the convert 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 [2].

The inorganic fire 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 .As example to inorganic flame retardants is magnesium hydroxide , zinc borate , aluminum hydroxide , and antimony oxides [3]. Antimony tetroxide is an inorganic compound with the formula $Sb_2O_4$ , which used as a flame retardant in engineering plastics due to its stability in high temperatures . $Sb_2O_4$ has a white color when cold but reversibly yellows upon heating

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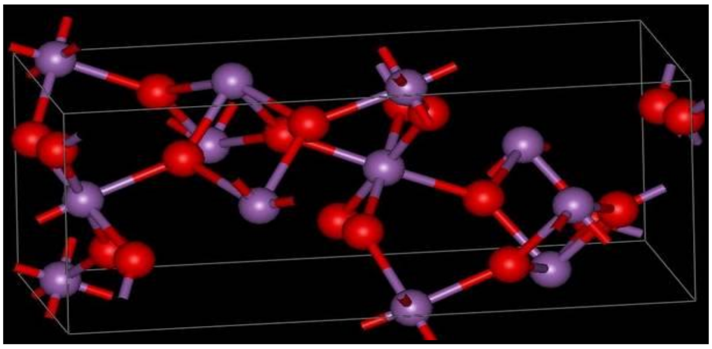
[4].**Fig.1** shows the structure of antimony tetroxide .



Fig( 1) : Structure of antimony tetroxide

## Materials and Methods :

The experimental work includes the following :

1- Materials Used .

a- Antimony tetroxide -$Sb_2O_4$: with particle size (2μ) .

b- Composite material : consist of (40%) epoxy resin type conbextra (EP-10) reinforced with (60%) volume fraction carbon-Kevlar fibers)$^o$ 90 - $^o$ 0 (.

2- Preparation of Test Samples.

Samples of thermal erosion test have a square shape with dimensions (100 ×100×10mm) which consist of two layers : Fire retardant material layer with (4mm) thickness represented by zinc borate. Composite material layer with (6mm) thickness.

3- Thermal Erosion Test .

Oxyacetylene torch with temperature (3000ºC) was used in this test. The system was exposed to this flame under different exposure intervals (10 ,15, 20mm). surface temperature method used here to calculate the amount of heat transmitted through fire retardant material and composite material. A transformation card (AD) which called Thermal monitoring and recording system **(Fig .2)** was used to observed and saved temperatures with time .

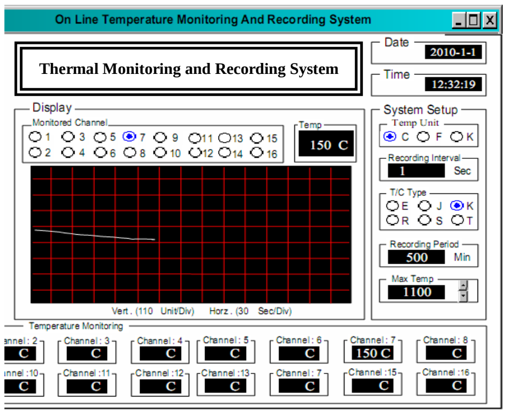



Fig ( 2): Thermal monitoring and Recording system

## Results and discussion:

**Fig .3** represent thermal erosion test with different exposed interval .The curve(1) with exposed interval (10 mm) show that the temperature of opposite surface to flame begins to increase with increasing time of exposed to flame and during this time ,antimony tetroxide absorbed heat and transformed to antimony trioxide which also a flame retardant .This represent endothermic process which decreased surface temperature as well as rise fall down of flame retardant layer and protect the substrate [5].

This state of absorbed heat and transformed to antimony trioxide will improved as the exposed interval increased to (15 mm) as shown in Curve(2), where the flame heat reached to antimony tetroxide layer will decreased [6]. So ,the breakdown of antimony tetroxide will delay and the resistance to heat as a result will rise .After that, antimony tetroxide will decomposed to antimony trioxide and the flame spread will retard by this oxide again ,and all this cause to increase the flame retardancy of composite material [7].

Curve(3) represents the thermal erosion test with exposed interval (20 mm) . As observed from this figure ,the resistance to flame will increased and the presence of antimony tetroxide will be longer due to decreased amount of heat reached to retardant layer .The endothermic reaction will continue until failure of this protect layer [8].

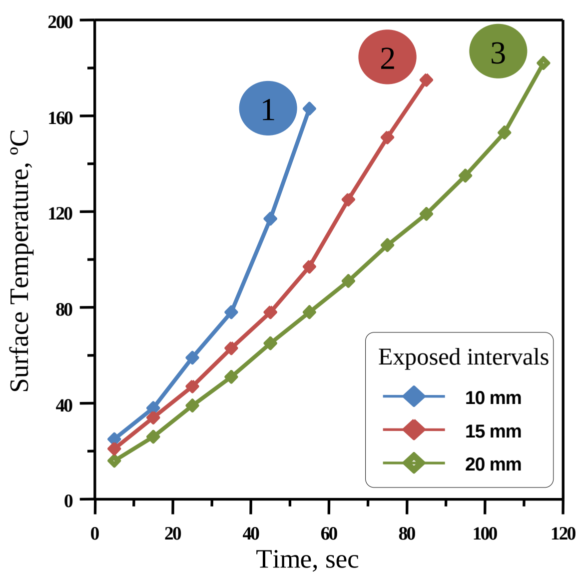



Fig (3): Thermal erosion test with different exposed intervals

## Conclusions :

From the results obtained by the thermal erosion test we concluded that :

Using antimony tetroxide improved the flame retardancy of composite. Enhancement flame resistance by break down of antimony tetroxide to trioxide. The optimum improving in flame retardancy was with exposed interval 20 mm.

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# صفات تثبيط اللهب للمواد المركبة البوليميرية

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**الخلاصة :**
صفات تثبيط اللهب لمادة مركبة بوليمرية مقواة بالألياف بإستخدام الطلاء بطبقة مثبط لهب متمثلة برابع أوكسيد الأنتيموون قد تم دراستها . تم إستخدام طبقة طلاء بسمك (4mm) من رابع أوكسيد الأنتيمون كطبقة طلاء سطحية لمقاومة ومنع إنتشار اللهب على سطح راتنج الإيبوكسي المقوى بألياف الكربون - كيفلار ، وتعريض هذه الطبقة للهب مباشر الناتج متولد من شعلة أوكسي أستيلينية مع مسافات تعرض مختلفة (10،15،20mm) ودراسة كيف تستطيع حماية الطبقة التحية. أظهرت النتائج العملية زيادة كبيرة في المقاومة الحرارية وتثبيط اللهب بعد طلاء برابع أوكسيد الأنتيمون وكذلك إرتفاع مقاومة اللهب مع زيادة مسافات التعرض .