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Short Communication

Increasing combusting Resistance for Advanced Composites by using Fire Retardants

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Abstract

The aim of this paper is to use inorganic fire retardant mixture consist of zinc borate- antimony trioxide to increase the fire retardancy for advanced composite material consist of araldite resin reinforced by carbon-Kevlar fibers .In first stage a surface layer from zinc borate as a coating layer of (4mm) thickness was used. Then, this system was exposed to a direct Oxyacetylene torch flame with flame exposure intervals 10,20mm, and study the range of resistance of retardant material layer to the flames and protected the substrate. The second stage was to form a hybrid fire retardant by added antimony trioxide with various amount (10%,15%,20%,25%,30%) to zinc borate for enhance the action of this material to react flame and exposure this hybrid material to same flame temperature and exposure intervals. Method of measuring the surface temperature opposite to the flame was used to determine the heat transferred to composite material. The best results were obtained with large exposed interval and large percentage from protective layer which is zinc borate with (30%) antimony trioxide.

Keywords: Fire retardancy, advanced composite, inorganic retardants.

Introduction

A fire-retardant coating or paint is intended to delay ignition and reduce the surface burning rate of a combustible wood, cellulosic fiber or cellular plastic building material for a short period of time. It may be applied as a thick protective covering by trowel or as a fire-retardant paint by brush, spray, or roller. The reduction of burning rate usually depends on the applied thickness[1]. In the case of a fire-retardant paint exposed to fire, the paint may intumesce, forming an insulating blanket which retards surface ignition and reduces the burning rate of the combustible material on the coated side. Fire-retardant coatings will effectively reduce the burning rate of a combustible surface for a period of about 10-15 minutes. Their use is particularly applicable in very low hazard occupancies not requiring sprinkler protection, where occupancy is not likely to change and the only hazard is that of exposed, interior finish materials [2]. Fire retardants commonly divided into four major groups: Inorganic FRs, organo phosphorus FRs, Nitrogen-containing FRs and Halogenated organic FRs[3]. Inorganic flame retardants make up a large part of the market encompassing various aluminum, nitrogen, phosphorous, and boron compounds[4]. These widely used low cost materials have been around for centuries, proven to be effective flame retardants in fibers in clothing and fillers for textiles. The majority of these inorganic flame retardants work by diluting both the condensed and vapor phase of the polymer with non-flammable salts, acids and by-products such as water and alumina (Al_2O_3) [5] . Figure-1 shows the mode action for inorganic FRs.

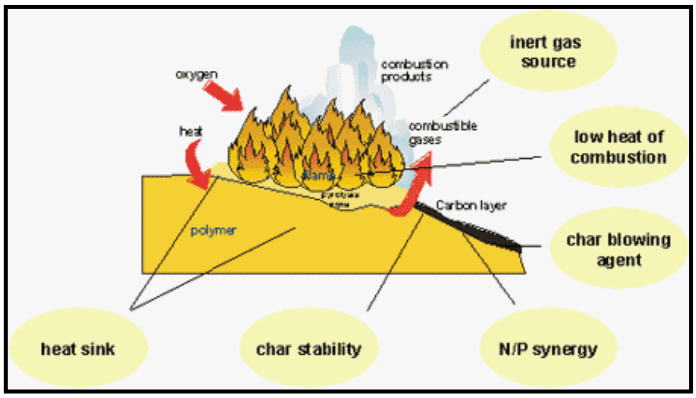

Figure-1
Mode of action for inorganic FRs

Polymeric plastic combustion occurs in the vapor phase. When a plastic is exposed to increased temperatures, the plastic undergoes pyrolysis. Potentially combustible vapors are slowly released at first. Since many polymers are substituted, the increase in surrounding temperatures can cause variations in connectivity among the monomer units [6]. Often, these variations in connectivity result in an overall weakening of the polymer structure and can encourage the release of more vapors and liquids, both flammable and non-flammable. As the heat source persists, the temperature of the polymer increases steadily[7].

Material and Methods

Materials Used: ($2ZnO.3B_2O_3.3.5H_2O$) Zinc Borate was used as a fire retardant, which supply by Akrochem corporation. Antimony Trioxide (Sb_2O_3): produced by NL Industries with particle size (1µ). Matrix material: Araldite resin (GY240), this resin was supplied by Huntsman Advanced Materials (Switzerland) GmbH. Reinforcing material: Woven roving (45 (0º - carbon - Kevlar fibers were used as a reinforcing material, the company supplied these fibers is Hyfil ltd., UK.

Preparation of Test Specimens: Specimen of thermal erosion test have a square shape, with dimensions (100×100×10mm). These Specimens consist of two layers: Fire retardant material layer with (4mm) thickness, and composite material layer with (6mm) thickness.

Thermal Erosion Test: Oxyacetylene torch Flame with temperature (3000ºC) was used in this test. The system (contains fire retardant material and composite material) was exposed to this flame under different exposure intervals (10, 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 (Figure-2) was used to observed and saved temperatures with time (in seconds) .

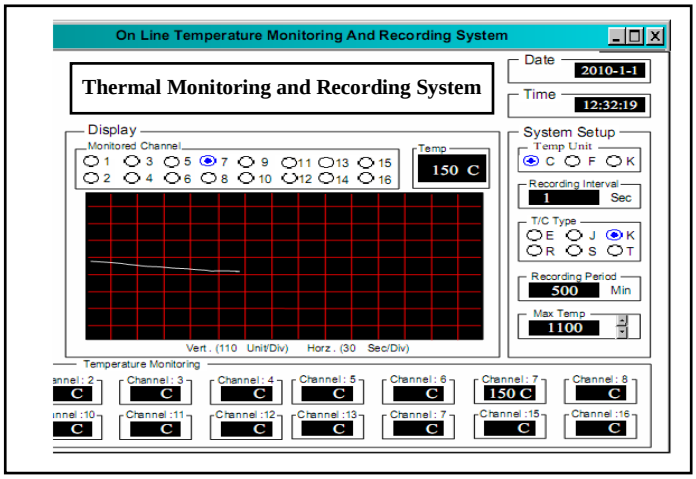

Figure-2
Thermal monitoring and recording system

Results and Discussion

Figure-3 represents the thermal erosion test for composite material with retardant 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. Zinc borate will form a glassy char at high temperatures that prevents flame propagation; it also releases water of hydration from its chemical structure. Therefore, the substrate (composite material) will protect and the fire spread will decrease[8]. This process of flame retardancy will be increased by addition antimony trioxide to zinc borate where zinc borate is a synergist with this oxide, so the combined ingredient will have better flame resistance than separate materials would have. When added (10%) from antimony trioxide to Zinc Borate ,the phase transformations happened in internal structure of this oxide which with zinc borate enhanced flame retardancy of composite materials , and this retardant action increased with increased antimony trioxide content to (15%, 20%, 25% and 30%) [9].

The improvement in flame retardancy will increased with increased exposed interval to (20mm) as shown in figure-4. As a result, when the exposed interval to flame increased to (20mm), the time necessary to break down of fire 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 comes from zinc borate, and this protection will improves with addition (15%, 20 %, 25% and 30 %)[10]. This process will rise the time of break down for zinc borate-antimony trioxide layer and substrate composite material[11]. From figures, the better results obtained with large exposed interval and large percentage from protective layer which is antimony trioxide (30%).

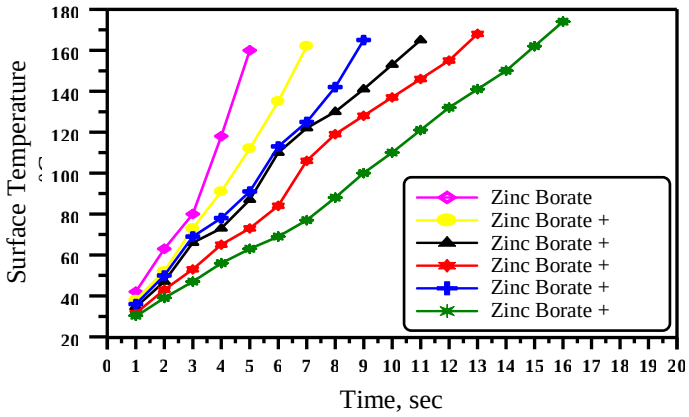

Figure-3
Exposed Interval (10 mm)

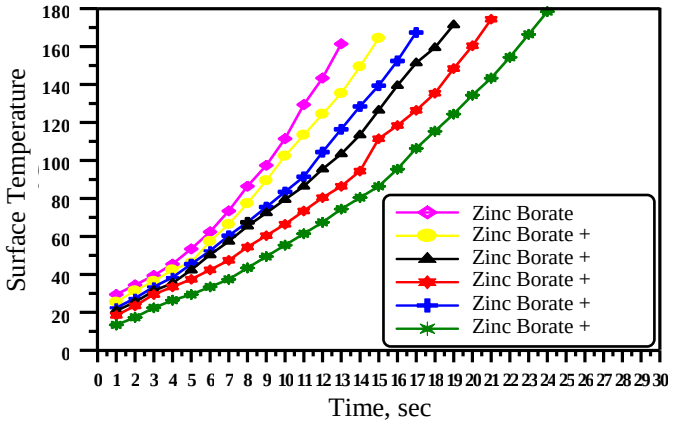

Figure-4
Exposed Interval (20 mm)

Conclusion

Flame resistance of composite material will enhanced with addition retardant layer from zinc borate ,and this action will improved when added antimony trioxide to zinc borate with different percentages and forming hybrid retardant material. The resistance to flame spread will increased with increasing of exposed interval. The flame retardancy is increased as the flame temperature is decreased. The mixing ratio of 3:1 (zinc borate: antimony tri- oxide) is the optimum mixing ratio which is obtaining the best result because after this percentage the retardant layer broken easily.

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