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Development Hybrid Retardant Agent and its Effect on Flammability Resistance of Composites

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Abstract

The maintain structural composite safety considered the greatest challenge to workers in this field to minimize and eliminated the dangerous of fires or completely removes through resist the flame generated from fires and terminated its activity. Zinc borate which represent inorganic fire retardant was used to coating structural composite consist of araldite resin reinforced with carbon and Kevlar fibers to increase the flame retardancy for these structures , where a surface layer from zinc borate was used as a coating layer of (4mm) thickness. The material was exposed to a direct flame generated from Oxyacetylene torch (3000ºC) with different flame exposure distances (10, 15, 20mm), and study the range of resistance of retardant material layer to the flames and protected the substrate. For enhance the action of zinc borate, a hybrid fire retardant was formed by added antimony trioxide with various quantities (10%, 20%, 30%) to zinc borate to react flame and exposure this hybrid material to same flame temperature and exposure distances. Method of measuring the surface temperature opposite to the flame was used to determined the heat transferred to composite material. The optimum results was obtained with (30%) antimony trioxide mixed with zinc borate and exposed distance (20mm).

Keywords: Hybrid retardant agent, composites, flammability resistance.

Introduction

Fire retardants (FRs) comprise a diverse group of chemicals which are widely used at relatively high concentrations in many applications, including the manufacture of electronic equipment, textiles, plastic polymers and in the car industry[1]. The use of (FRs) is primarily to protect materials against ignition and to prevent fire-related damage. Room combustion tests comparing FR plastics with non-FR plastics conducted by the National Bureau of Standards (The National Institute of Standards and Technology) have shown that FR materials allow longer escape time, less heat release, less smoke and release of a lower concentration of toxic gases.

These effects are due to a decrease in the amount of burning materials[2]. Fire retardants commonly divided into four major groups: Inorganic FRs, Organo phosphorus FRs, Nitrogen-containing FRs and Halogenated organic FRs. Depending on their nature, fire retardants can act physically or chemically[3].

Inorganic FRs comprise metal hydroxides (e.g. aluminum hydroxide and magnesium hydroxide), ammonium polyphosphate, boron salts, inorganic antimony, tin, zinc and molybdenum compounds, as well as elemental red phosphorous. Inorganic FRs are added as fillers into the polymers and are considered immobile, in contrast to the organic additive FRS[4].

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 [5]. 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 [6].

Volatile vapor release rates increase and hydrogen and hydroxide radicals diffuse out of the material. The radicals can combine to propagate the flame spread. Re-radiation from combusting vapors effectively increases the polymers' temperature[7]. During this process a char layer forms on the surface of the plastic which serves to inhibit flame spreading. If there is enough char barrier, the flame will slowly extinguish. Otherwise, heat will continue to be released at higher rates and the pyrolysis-combustion process continues. So the flame retardants used with these materials to inhibiting combustion process[8].

A composite is a structural material that consist of two or more constituents that are combined at a macroscopic level and are not soluble in each other[9]. One constituent is called the reinforcing phase and the one in which it is embedded is called the matrix[10]. The composite material however, generally possesses characteristic properties, such as stiffness, strength, weight, high-temperature performance, corrosion resistance, hardness and conductivity that are not possible with the individual components by themselves[11]. Fiberglass sheet is a composite since it is made of glass fibers imbedded in a polymer. Composite materials are said to have two phases[12]. The reinforcing phase is the fibers, sheets, or particles that are embedded in the matrix phase[13]. The reinforcing material and the matrix material can be metal, ceramic, or polymer[14]. Typically, reinforcing materials are strong with low densities while the matrix is usually a ductile, or tough, material[15].

Material and Methods

Materials: the following materials was used in this paper: Zinc Borate ($2ZnO.3B_2O_3.3.5H_2O$) was used as a fire retardant, which supply by Akrochem corporation. Antimony Trioxide (Sb_2O_3) : with particle size (1μ) and produced by NL Industries. This trioxide was added to zinc borate with a various quantities (10%,20%,30%). Araldite resin (GY 2600) . this resin produced by Huntsman Corporation. woven roving fibers ° - 45°) (0Carbon fibers. woven roving fibers (0° - 45°) Kevlar fibers.

Fabrication of test samples: sample of thermal erosion test shown figure-1 have a square shape, with dimensions (100×100×10mm), which can be fabricated by the hand layup technique using laboratory compression moulding machine[16].

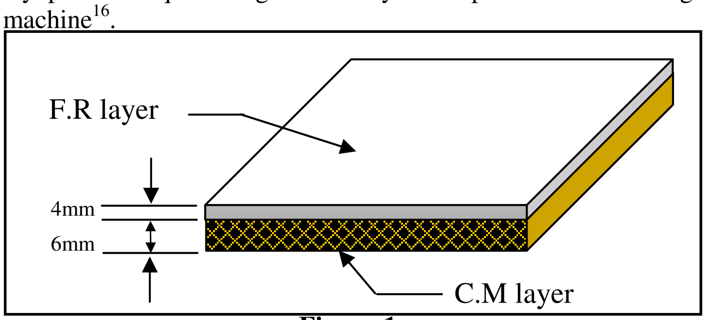

Figure-1
Sample of thermal erosion test

Experimental procedure of thermal erosion test: thermal erosion test by Oxyacetylene torch 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 distances (10, 15, 20mm).

Determination of heat transmitted through fire retardant: surface temperature method used here to calculate the amount of heat transmitted through fire retardant and composite material. Figure-2 shown the transformation card (AD) which was used to observed and saved temperatures with time in seconds.

Results and Discussion

Figure-3 represents the thermal erosion test for composite material with retardant surface layer at exposed distance (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[17]. 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[18]. When added (10 %) 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 (20 %, and 30 %)[19].

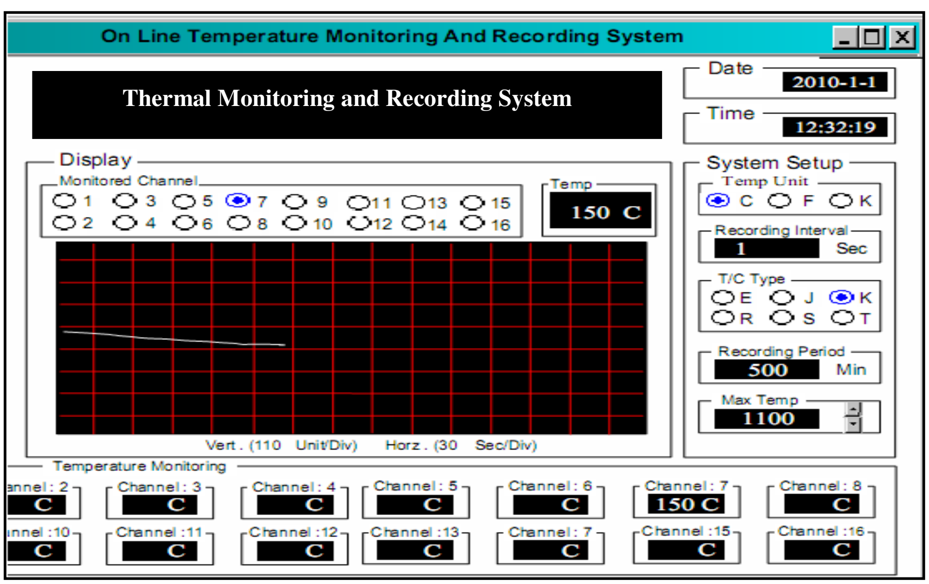

Figure-2
Thermal monitoring and recording system

Figure-4 represent the thermal erosion test for retardant surface layer with exposed distance (15mm). As a result, when the exposed distance to flame increased to (15mm), 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. This protection will improves with addition (10%, 20%, 30%) from antimony trioxide because the mode action of this oxide with glassy coating layer increasing flame retardancy[20]. The improvement in flame retardancy will increased with increased exposed distance to (20mm) as shown in figure-5. All that will rise the time of break down for zinc borate- antimony trioxide layer and substrate composite material[21]. From figures, the optimum results was with (20mm) exposed distance and (30%) antimony trioxide.

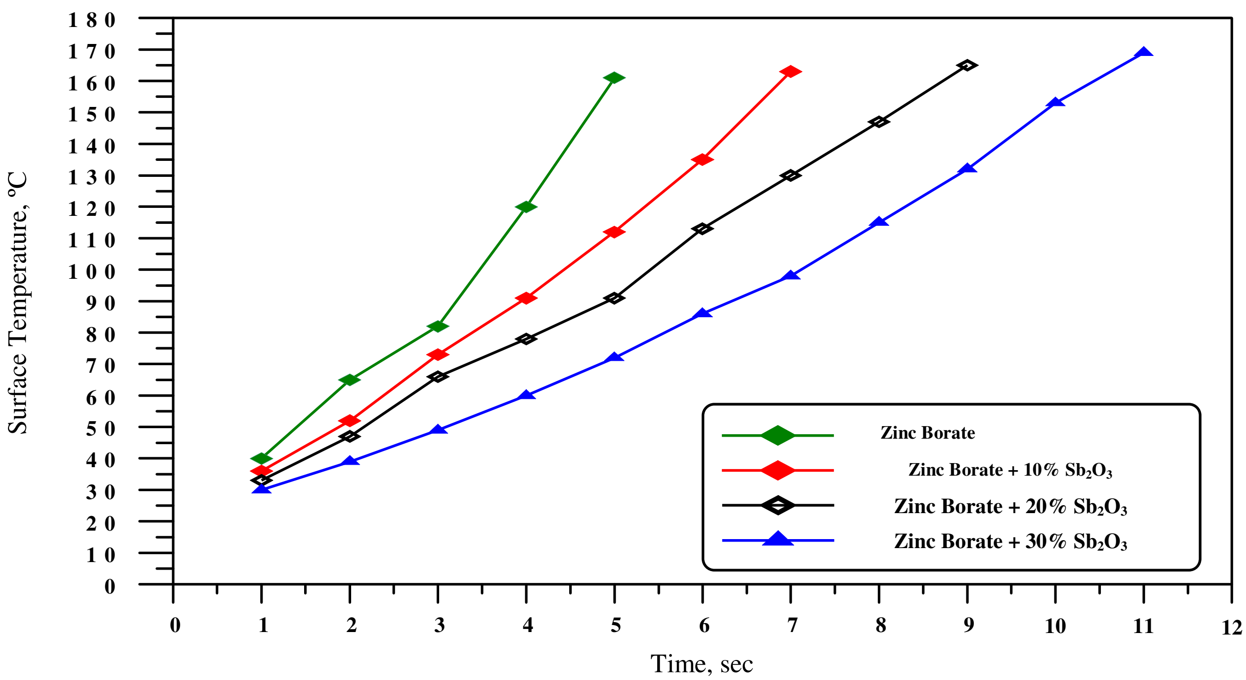

Figure-3
Exposed distance 10 mm

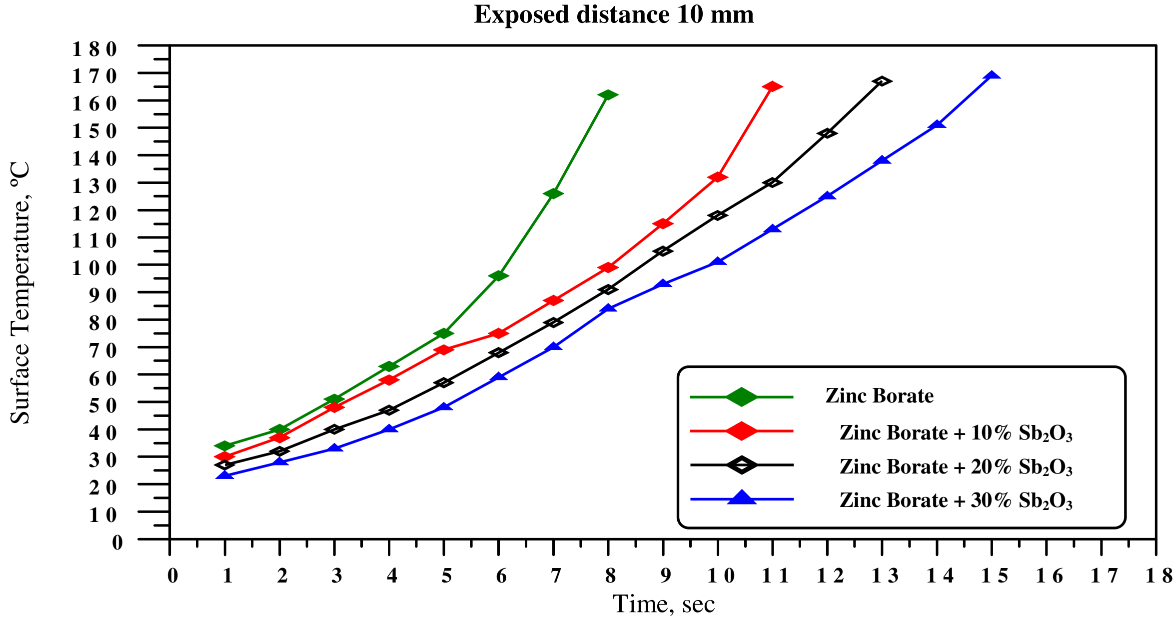

Figure-4
Exposed distance 15 mm

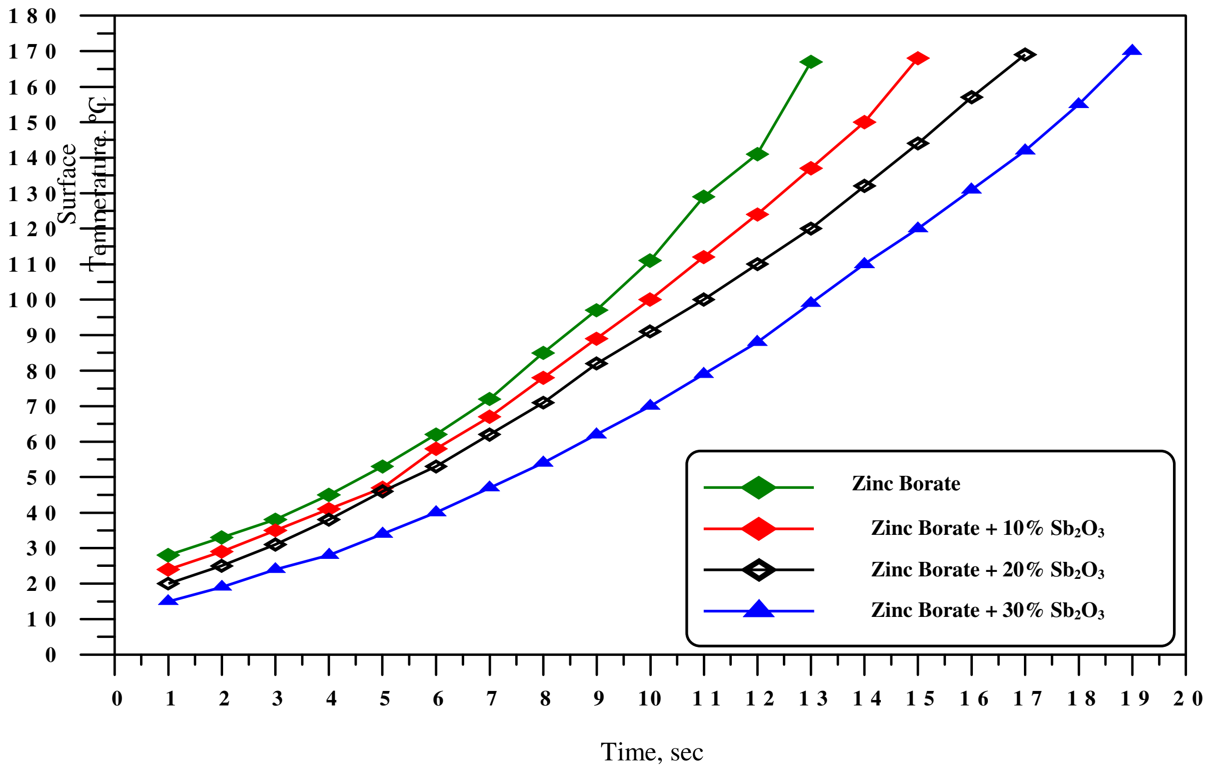

Figure-5
Exposed distance 20 mm

Conclusion

An experimental method has been developed to improvement flame retardancy for composite material during combustion process by addition zinc borate and as a retardant layer. Increasing the flame retardancy 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 distance and the optimum percentage from antimony trioxide was (30%) . The flame retardancy is increased as the flame temperature is decreased.

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