ISSN-L: 2223-9553, ISSN: 2223-9944
Vol. 4 No. 3 May 2013

Academic Research International

FLAMMABILITY OF POLYPROPYLENE BASED COMPOSITE MIXED WITH INORGANIC RETARDANTS

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ABSTRACT

Flammability of polypropylene based composite mixed with zinc borate - antimony pentoxide has been investigated. Retardant layer added on external surface of composite material with (4mm) thick, and tested by thermal erosion test. Antimony pentoxide was added with (10%, 20% and 30%) quantities to zinc borate for enhance the action of this material to react flame. This new retardant was exposed to Oxyacetylene torch flame with (10mm and 15mm) exposure intervals, to study the combustion behavior and resistance of retardant layer to the flame. Thermal erosion test shows that, the large exposed distance and large percentage from protective layer which is zinc borate-(30%) antimony pentoxide is the optimum parameters in flame retarding.

Keywords: Polypropylene based composite, Flame Retardant, Thermal erosion test

INTRODUCTION

Flame retardants are used in plastics because they increase the material's resistance to ignition, and once ignition occurs they slow down the rate of flame spread. A combustible plastic material does not become noncombustible by incorporation of a flame-retardant additive. However, the flame-retardant polymer resists ignition for a longer time, takes more time to burn, and generates less heat compared to the unmodified plastic [1]. The successful use of flame retardants in thermoplastics is a compromise or at best a balancing act. Filler-type additives of optimum particle size must be properly dispersed, and processing temperatures have to be chosen to prevent degradation.

Brittleness and poor impact properties can result from non-uniform dispersion of such solid additives. Melt blend-able additives of low molecular weight will plasticize high-molecular-weight polymers depending on polarity, size, and concentration in the polymer. Heat distortion temperature is drastically decreased upon incorporation of such plasticizing additives. Light and heat stability can suffer especially with incorporation of halogenated materials. [2].

Zinc borate is an effective inorganic flame retardant and it possesses characteristic properties of flame retardancy (FR), smoke suppression, promoting charring, etc. particularly important according to new fire standards. Zinc borate is commonly used as multifunctional flame retardant in combination with other halogenated or halogen free flame retardant systems to boost FR properties. Its efficacy depends upon the type of halogen source (aliphatic versus aromatic) and the used polymer. The zinc borate can generally display synergistic effects with antimony oxide in fire retardancy [3].

Antimony oxides are known to exist in several different compositions and display polymorphism, Sb_2O_3, Sb_2O_4, and Sb_2O_5. Antimony trioxide (Sb_2O_3) are cubic phase (Senarmontite) which colorless and Orthorhombic phase (Valetinite) which have white color.

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Antimony trioxide dissolved slightly in water and dissolved in potassium hydroxide, dilute hydrochloric acid and with many organic acids [4].

EXPERIMENTAL SECTION

Materials and processing

Ultra-fine zinc borate ($2ZnO.3B_2O_3.3.5H_2O$) was supplied respectively by Joseph Storey & Co. (UK), Antimony pentoxide (Sb_2O_5): supplied by BDH Chemical Ltd Pool England), and Composite material: which consist of polypropylene resin reinforced by ceramic fibres, as woven roving fibres (º0 - 45°).

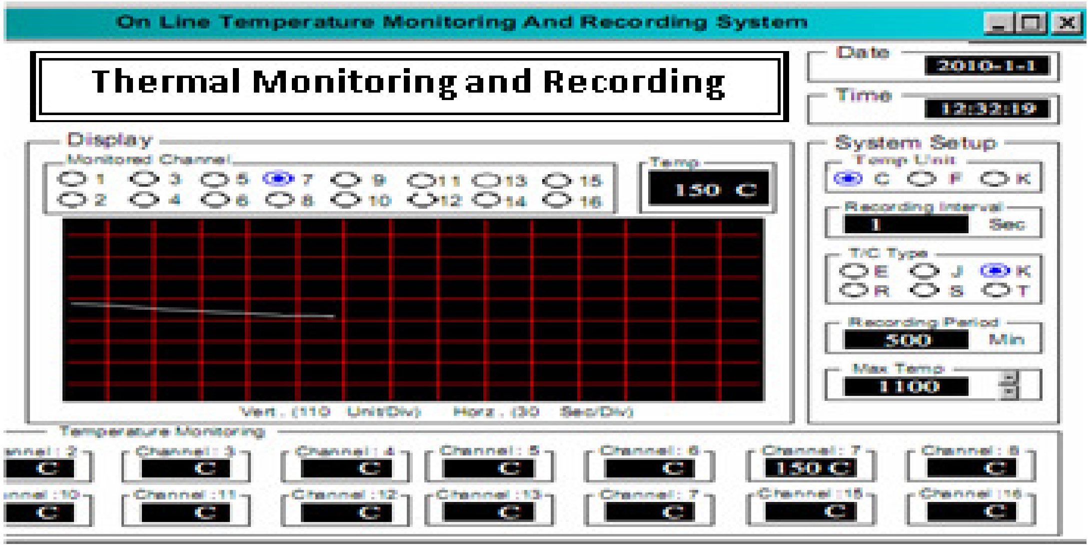
Preparation of Test Samples

The composite laminate of 80 mm ×10 mm was built up in metal mould by a conventional hand lay-up technique. The resultant composite with (6mm) thickness was coated by hybrid flame retardants, primarily by zinc borate followed by different toughened percentages of antimony pentoxide (10, 20,30 wt. %) consecutively using spray-coating deposition technique to make a total coating layer of 4 mm

Thermal Erosion Test

A direct source of flame generated by oxyacetylene torch with temperature almost of (3000 ℃) was depended in order to conduct the thermal erosion test as standard BS 476-4:1970 Non-Combustibility. The system (contains flame retardant material and composite material) was exposed to this flame under different exposure intervals (10,15mm). The measurements of the face surface temperature and the opposite surface temperature of the coated composite were done via a thermocouple as indication for the pyrolysis resistance of the composite.

A transformation card (AD) which called Thermal monitoring and recording system (Figure 1) was used to observed and saved temperatures with time (in seconds) . Temperatures measured by thermocouple type-K in opposite surface. Any changed in temperatures and time will appears in computer.



Date 2010-1-1
Time 12:32:19
Monitored Channel: ● 7
Temp 150 C
Temp Unit: ● C ○ F ○ K
Recording Interval 1 Sec
T/C Type: ○ E ○ J ● K ○ R ○ S ○ T
Recording Period 500 Min
Max Temp 1100
Vert . (110 Unit/Div) Horz . (30 Sec/Div)
Channel : 7 150 C

Figure 1. Thermal monitoring & recording system

RESULTS AND DISCUSSION

Figure 2 represents the relationship between surface temperatures of the coated composite and the exposure time for the direct flame at exposure interval (10mm) away from the flame. It is obviously clear from the figure that the surface's temperature of the composites increases with increasing the time of exposure to flame. While, the composites endure longer time before deforming by fire which is ascribed to that zinc borate forms a glassy char at high temperatures and releases water of hydration from its chemical structure which in turn prevents the flame propagation .

This process of flame retardancy will be increased by addition (10 %) from antimony trioxide because its phase transformations happened in internal structure of this oxide which cause with zinc borate enhanced flame retardancy of composite materials , and this retardant action increased with increased antimony trioxide content to (20 %, and 30 %) [7].

Figure 3 the thermal erosion test for composite material with retardant surface layer with exposure interval (15mm). As a result, when the exposure interval to flame increased to (15mm), 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 comes from zinc borate, and this protection will improves with addition (10% ,20 %, and 30 %) from antimony pentoxide .

This perhaps due to the mode action of this oxide with glassy coating layer which results in flame retardancy enhancement. In general, using FRs materials tend to reduce the heat distortion temperature and melt dripping for polymer based composite at high temperature [6].

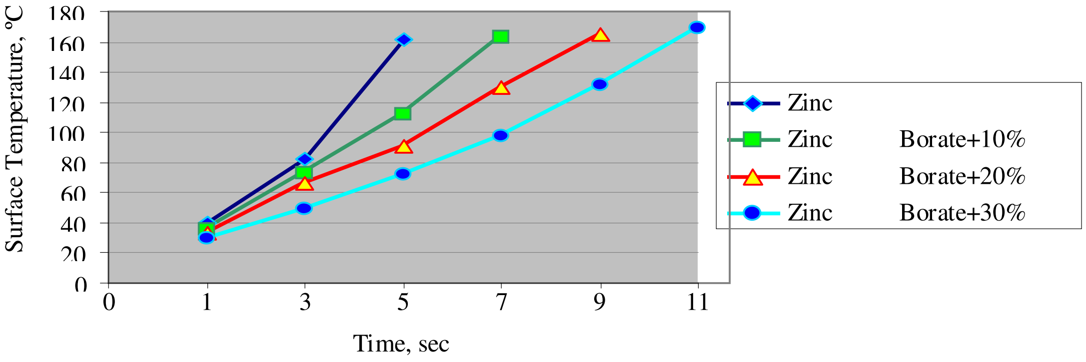


Figure 2. Exposure interval (10 mm)

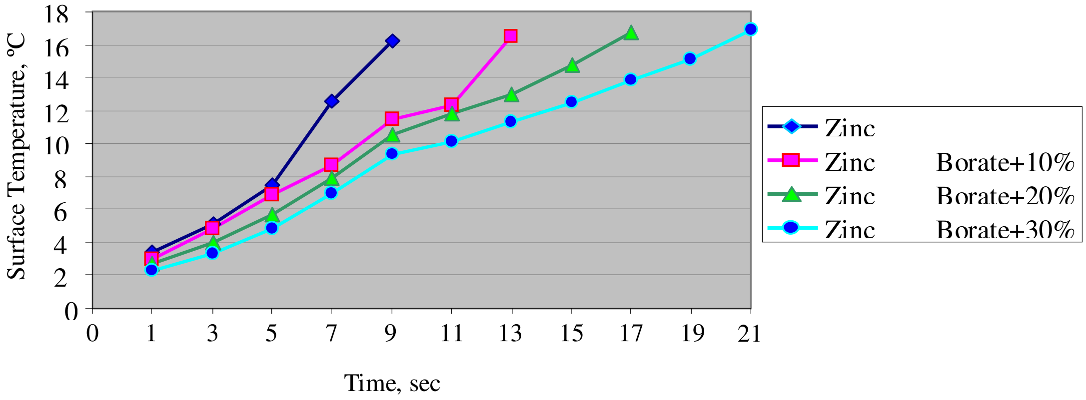


Figure 3. Exposure interval (15 mm)

CONCLUSIONS

From the obtained results we get: Using Zinc borate improved the flame retardancy of composite. Adding Antimony pentoxide to Zinc borate improved the layer Durability and structure. The results of the time required to break down the coated layer of the composite increased due to forming the complex char from the interaction between the resin-intumescent-ceramic fibres which created due to the synergistic effect of the zinc borate-Sb_2O_5 flame retardant material ,and the optimum mixing ratio was 3:1 (zinc borate: Sb_2O_5) which is obtaining the best result.

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