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RESEARCH ARTICLE

Flame Retardancy of Biopolymer Polyhydroxyalkanoate Composite

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Abstract

In this paper, flame retardancy of Biopolymer Polyhydroxyalkanoate (PHA) was studied. ASTM E162 standard test method for surface flammability was used to assess the functioning of the aluminum hydroxide nanoparticles efficiency as a surface layer with (4mm) to impede flame by using oxy-acetylene torch with exposed intervals equal to (20mm,30mm). The results obtained from surface flammability test were evidenced that the aluminum hydroxide was effective as a flame retardant to impede the flame.

INTRODUCTION

Flame retardants are materials that are incorporated into a variety of materials to reduce the risk of fire injuries and damage by providing increased resistance to ignition or by acting to slow down combustion and thereby delaying the spread of flames[1]. Flame retardants differs from each other's by common chemical or physical properties and mode of action[2]. the use of flame retardants is to prevent the flame from entry into the material, as well as prevent the spread of flame and even extinguished completely [3]. The use of flame retardants is especially important today because many of the products and synthetic materials present in modern homes present a greater risk of fire dangers [4].

According to the National Fire Protection Association, over a million fires occur each year in the United States which cause thousands of deaths and tens of thousands of injuries [5].

Flame retardants are one of the hidden layers of protection against the potentially devastating impact of fire. Their benefits are often noticed only when they are not present or not used appropriately[6]. Modern technologies have generated a host of new issues related to fire safety. The increased use of electrical and electronic equipment, for example, has led to a corresponding increase in potential ignition sources in the home[7]. Manufacturers from a wide range of sectors have addressed these potential fire risks and, as a result, consumers have grown to expect modern-day products to be fire safe. A range of industries – from electronics to construction to automotive- have addressed fire safety by developing technical standards for particular components or products where there is a potential fire danger[8]. Some flame retardants cause a treated cloth to char, thus inhibiting the pyrolysis process . Others remove flammable gases by reacting with the hydrogen and hydroxide radicals in the air. On that point are four primary substances which work to retard fire in different ways. These families include halogenated, phosphorus, nitrogen and inorganic flame retardants [9].

The inorganic flame retardants are performed 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, a glassy protective layer can form on the substrate fending off the effect of oxygen and heat. As example to inorganic flame retardants is aluminum hydroxide, zinc borate, magnesium hydroxide and antimony oxides [10].

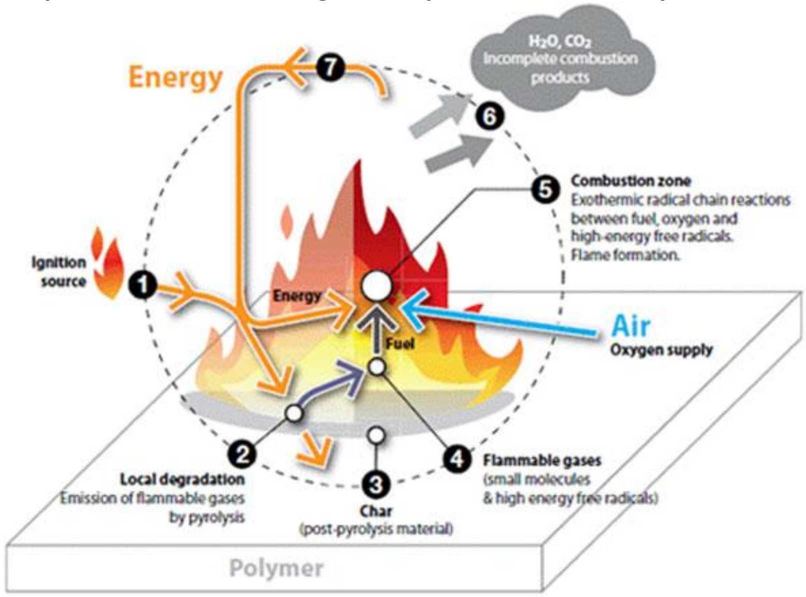

Fig.1: Action of flame retardant [1]

Biopolymers or organic plastics are a form of plastics derived from renewable biomass sources such as vegetable oil, starch, proteins etc, unlike fossil-fuel plastics which are derived from petroleum. Biopolymers provide the dual advantages of conservation of fossil resources and reduction in CO_2 emissions, which make them an important innovation of sustainable development [11]. In recent years more and more biopolymers have been studied by researchers revealing a large range of possible sources from which they can be obtained and an increasing range of applications that bioplastic produced from them can fulfill[12].

2. Methodology

2.1. Materials.

Aluminum hydroxide nanoparticles (10nm $Al(OH)_3$, High purity, 99.9%, Hydrophilic) was used as a flame retarding coating layer of (4mm) thickness , and was supplied by US Research Nanomaterials, Inc. Composite material consist of Biopolymer Polyhydroxyalkanoate reinforced with palms fibers (40% biopolymer + 60% fibers).

2.2. Sample Fabrication.

Sample of thermal erosion test has a square shape, with dimensions (100×100×10mm). These Samples consist of two layers, Fire retardant material layer with (4mm) thickness, and composite material layer with (6mm) thickness.

2.3. Surface Flammability Test.

ASTM E 162 standard test method for surface flammability was used . Oxy- acetylene torch with ~3000 ºC was used in this test with exposed intervals equal to (20mm,30mm). A transformation card (AD) which called Thermal monitoring and recording scheme (see Fig.2) was used to observed and saved temperatures with time (in seconds).

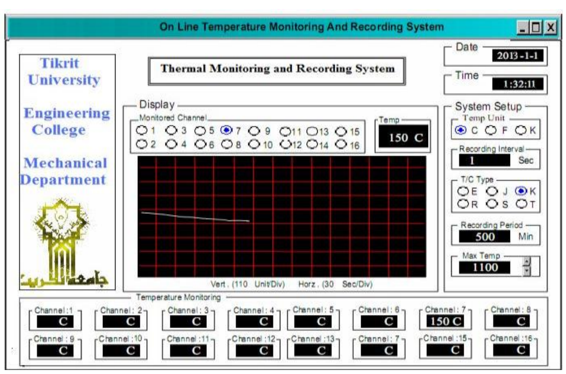

Fig.2: Thermal monitoring and transcription scheme

3. Results and Discussion.

Fig.3 Curve.1 represents the surface flammability test for biopolymer composite with retardant surface layer at exposed interval (20mm), the temperature of the opposite surface to the torch begins to increase with increasing the time of exposition to the flame. Aluminum hydroxide 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. Fig.3 Curve.2 represents the surface flammability test for biopolymer composite with retardant surface layer ont exposed interval (30 mm), where this increment in exposed interval will rise the time of breakdown for aluminum hydroxide layer and substrate composite material.

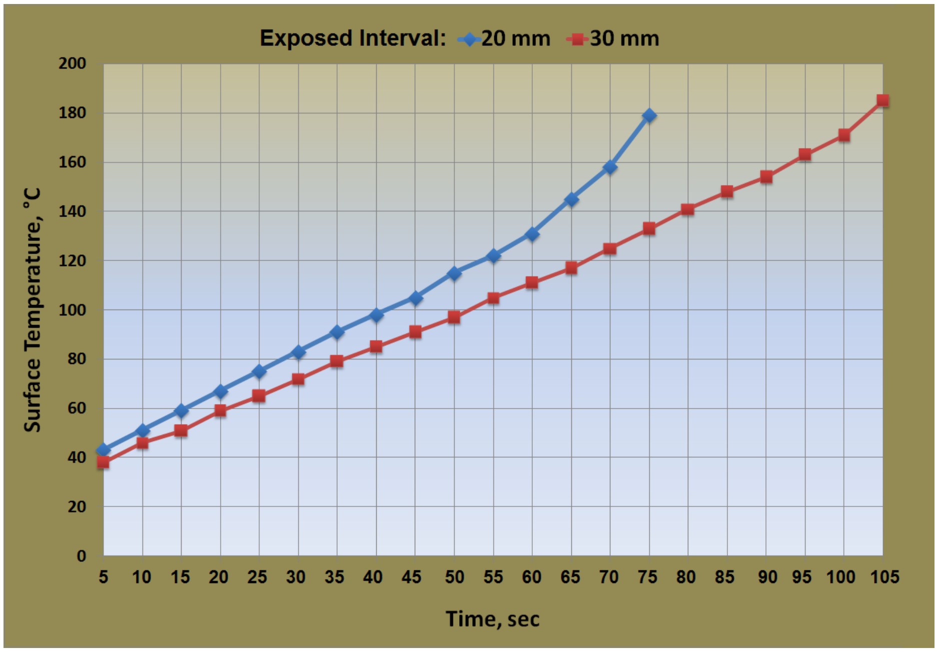

Fig.3: Thermal Erosion Test

4. Conclusions

From the results obtained by surface flammability test we concluded that: using aluminum hydroxide improved the flame retardancy of biopolymer composite, where it raise the thermal resistance of the resin of from about 180°C (melting point) to make it resistant to elevated temperatures.. The resistance to flame spread will increased with increasing of exposed distance.

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