THE PERFORMANCE OF EXPANDABLE GRAPHITE BASED INTUMESCENT FIRE RETARDANT COATING

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Introduction

Intumescent fire retardant coating consists of three essential components; carbon, acid, and gas [1]-[3] a carbon source; a carbon-rich polyhydric compound, such as glucose, starch, and pentaerythritol. An acid source is a dehydrating agent that reacts with the carbon source to form carbonaceous char, and generally a phosphoric acid source, such as ammonium phosphate (APP), diammonium phosphate, and the other phosphates. A gas source expands the carbonaceous char of the coating with the release of gaseous products upon heating, is usually a source of nitrogen or halogen releasing compounds such as melamine and melamine phosphates, urea, or chlorinated paraffin [4]-[6].

The initial intumescent coating was based on starch, APP, and urea-formaldehyde. This product would stink of formaldehyde and is not percolate resistant [7]. At present, there is a new development of intumescent coatings. For example, a new carbon source is dispersed in polyurethane to improve the coatings' weather durability [8]. Water-insoluble acid sources and gas sources (such as melamine pyrophosphate [9], melamine polyphosphate, and melamine polymetaphosphate) have been studied to attain better fire retardancy [10] of intumescent coatings. In earlier research [11]-[13], it has been shown that the combination of ammonium polyphosphate derivative (APP) and boric acid provides an intumescent behaviour to an epoxy-based coating. It was observed that their proper blend inside the resin led to char expansion; the char that

formed had good adhesion to steel plates, but this relationship has not been further clarified.

Hanafin et al. [14] described that typical intumescent coating contains at least one epoxy resin, which functions as a binder, at least one char forming agent, at least one spumific, and at least one epoxy curing agent. Char forming agent causes the formation of char when the intumescent coating is exposed to fire. Char-forming agents control the rate and mechanism of thermal decomposition of epoxy, resulting in the formation of carbonaceous char instead of carbon dioxide, carbon monoxide, and water. The common component in fire retardant for char forming agents is phosphorous. Pollak [15] stated two types of intumescent coating available; water-based or solvent-based coatings. There are two materials added to support the intumescent coating, which are primer and topcoat. The primer's purpose is to enhance the intumescent coating's adhesion to the substrate. At the same time, the topcoat provides a decorative appearance (e.g., color, gloss) or enhances the durability of the coating. However, the primer and topcoat must be chemically compatible with the intumescent coating. According to Pollak, water-based products might not accept epoxy, hence will not have proper adhesion.

Jimenez et al. [16] reported that the coating surface's temperature reaches a critical level under the flame's heat. When this happens, the coating surface begins to melt and is changed into a highly gummy fluid. Concurrently, reactions have been instigated that result in the release of inert gases with low thermal conductivity. The response leads to expanding the carbonaceous char, up to several times its original coating thickness, to form a protective carbonaceous char that works as an insulative barrier between the fire and the substrate.

This chapter aims to investigate the effects of boric acid, ammonium polyphosphate, expandable graphite and melamine on char expansion, morphology, and thermal degradation of the intumescent fire-retardant coating.

Materials and Methods

Flake graphite (150µm), melamine (Mel), and boric acid (BA) were purchased from Sigma-Aldrich (M) Sdn Bhd. Malaysia. Clariant (Malaysia) Sdn Bhd provided ammonium polyphosphate (APP). Acetic acid, sulphuric acid, $KMnO_4$, the binder is bisphenol A epoxy resin BE-188 (BPA), and ACR Hardener H-2310 polyamide amine was bought from Mc-Growth chemical Sdn Bhd. Malaysia. Structural steel A36M was supplied by TSA industries (Ipoh) Sdn. Bhd. Malaysia.