THE INFLUENCE OF METALLIC OXIDE FILLERS ON THE THERMAL PERFORMANCE OF FIRE RETARDANT COATINGS

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Introduction

This chapter significantly discusses the effect of micro and nano-sized fillers on the thermal insulation properties of the intumescent fire-retardant coating. Mineral fillers such as alumina, talc, alumina trihydrate (ATH), and fumed silica were used for that purpose. The effects of inorganic fillers on the fire protection performance were discussed based on the result obtained from furnace test, TGA, SEM, XRD, XPS, FTIR, and Bunsen burner test. IFRC improved char expansion, residual char weight, and char morphology from the analysis of results and inorganic fillers in the controlled formulation. All inorganic fillers reduced the substrate temperature, thus protecting the substrate from high temperature. The rapid progression in technology is bringing grave concern to the safety of structures and human lives. Structural steel is a popular material used in constructing bridges, buildings, ships, cars, and offshore structures; thus, structural steel's integrity plays a vital role in the safety of structures and humans. At the time of the fire, a steel structure starts losing its load-bearing capacity at approximately 500°C. The steel begins to deform, buckle, twist, or distort, leading to its collapse [1]. As a prevention method, a passive fire protection system such as intumescent fire-retardant coating is applied to the structure to protect the steel substrate and prevent the collapse of the building structure in case of fire. Previous research has shown the APP-PER-MEL system as the traditional method of intumescent fire-retardant

coating. However, Li et al. [2] claimed that this system's performance was unsatisfactory because of anti-oxidation's poor performance. As a result, APP-PER-MEL coating is easily oxidised and detached from substrate material at high temperatures. On the other hand, Wang et al. [3]-[4] found that the APP-PER-MEL system tends to produce a fluffy fire-retardant barrier, easily penetrated by fire. Finally, the traditional intumescent fire retardant system could only perform for a short time and could not prevent fire spread.

Due to the poor performance of the traditional APP-PER-MEL system, researchers investigated and emerged with the idea of adding the inorganic fillers in the fire-retardant system. Inorganic fillers such as alumina, talc, alumina trihydrate (ATH), fumed silica, and titanium dioxide has been used to enhance a fire's performance retardant system. Wei et al. [5] have used alumina-filled polypropylene (PP) in their research work, showing improved flame retardant behaviour. Besides, Almeras et al. [6] added talc in the PP/APP/PA-6 system, facilitating the thermal properties by forming a protective ceramic char shield. On the other hand, ATH has been used widely due to its fire-retardant performance by cooling the surroundings and creating a protective char layer [7]. Ye et al. [8] used fumed silica in their research and found that a suitable amount can improve a compact intumescent charred layer formation. In contrast, Wang et al. [9] added nano-titanium oxide and enhanced coating's thermal stability while achieving permanent stability under UV exposure. After all, each inorganic filler used previously has demonstrated different effects in improving the intumescent fire retardant coating system.

Mineral Fillers in IFR Coatings

Based on research from the University of Pretoria [10], introducing inorganic filler to the compounds used as a flame retardant can finer their fire protection efficiency. It was considered due to certain fillers' plate-like structures that led to the stabilising effect of the cell structures. However, the addition of the inorganic filler can decrease the amount of intumescent char. However, it could give strength to the char structure. Bertelli et al. [11] reported that fillers modified the char structure but reduced the flame retardant system's efficiency. Char added with the fillers were more rigid than those without fillers but were lesser in volume. Almeras et al. [6] modified PP with the addition of fillers to reduce the cost. High modulus, excellent chemical resistance, and easy processing are the main advantages of polymer containing