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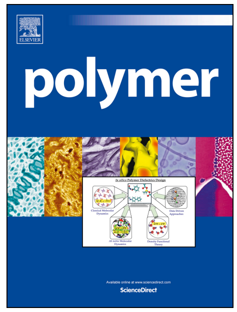

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Layered Double Hydroxide-Based Fire Resistant Coatings for Flexible Polyurethane Foam

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ABSTRACT: Montmorillonite clay (MMT) is frequently used to create fire resistance in Layer-by-Layer (LbL) applied coatings. This manuscript reports that switching the MMT with layered double hydroxides (LDH) produced a more effective fire resistant coating on flexible foam. Most of the formulations required at most two trilayers (TL) to produce ignition resistant and very low heat release rate polyurethane foam. The best coating (greatest flammability reduction with the least amount of coating) delivered a 41% reduction in peak heat release rate. This was a 2TL, 10% mass coating produced using a coating solution with a high LDH content. This manuscript discusses the impact of the LDH-based coating formulations and number of monolayers on the LbL coating growth rate, composition, and fire resistance.

1. INTRODUCTION

In the United States, there are more than 366,000 residential fires each year. Annually, these fires cause more than 2,500 civilian fatalities and 13,000 civilian injuries.[1] Though one of the lowest in frequency, fires involving residential furniture and mattresses are responsible for the largest fraction of these fatalities and injuries. To significantly reduce the fire severity of soft furnishings, it is critical to eliminate the flexible polyurethane foam from participating in the fire. However, existing fire retardant technologies are not viable options due to their ineffectiveness, and their banning because of potential environment and health concerns. One approach showing significant promise as a "greener" fire retardant for flexible polyurethane foam and textiles is fire resistant coatings fabricated by Layer-by-layer (LbL) assembly.

Over the past 20 years, LbL assembly has been used to create multifunctional films[2-4] for a variety of applications, such as sensing,[5,6] antimicrobial surfaces,[7] battery electrodes,[8,9] water repellents,[10,11] oxygen barriers,[12,13] fire resistance[14-17]. and drug delivery and biomedical applications[18-20]). As the name suggests (Layer-by-Layer), the films were assembled/fabricated by depositing one layer (a monolayer) at a time. The LbL films can be constructed of several hundred monolayers and are generally less than one micrometer thick.[21] The monolayers can be a polymer, additive, nanoparticle or a mixture of multiple materials.

A majority of these thin multilayer LbL films were constructed from a two monolayer repeat unit (AB) that was held together by electrostatics. More recently, trilayer (ABC, TL)[14,22] and quadlayer (ABCD, QL)[23] constructions were reported, which produced properties not easily achieved by the conventional BL construction. Others forces used to hold the films together have been covalent[24,25] or hydrogen bonds[26,27]. In addition to changing the materials and the construction, the film properties (e.g., transparency and permeability) have been controlled by changing the conditions of the depositing solutions, such as pH,[28,29] temperature,[30,31] and ionic strength[32] and molecular weight[32,33] of the coating materials.

In 2009, Grunlan (Texas A&M) et al. first published using Layer-by-Layer (LbL) assembled coatings to produce a low flammability fabric.[34] Since then, researchers have developed LbL FR coatings for textiles,[34-36] plastic plaques,[37-39] and polyurethane foam (PUF)[40,41]. The coatings were constructed of synthetic and bio-based polymer binders (e.g., polyacrylic acid and DNA),[42] and have contained a wide range of fire retardants and protective residue formers (e.g., montmorillonite clay,[16,33,34] silica,[43-45] α-