Materials Science & Engineering Doctoral Defense

Carbonaceous Nanomaterials as Flame Retardant Coating on Fabric

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abstract

Flame retardant materials (FRs) are applied to variety of consumer products such as textiles and polymers for fire prevention and fire safety. Substantial research is ongoing to replace traditional FRs with alternative materials that are less toxic, present higher flame retardancy and result in lower overall exposure as there are potential health concerns in case of exposure to popular FRs. Carbonaceous nanomaterials (CNMs) such as carbon nanotubes (CNTs) and graphene oxide (GO) have been studied and applied to polymer composites and electronics extensively due to their remarkable properties. Hence CNMs are considered as potential alternative materials that present high flame retardancy. In this research, different kinds of CNMs coatings on polyester fabric are produced and evaluated for their use as flame retardants. To monitor the mass loading of CNMs coated on the fabric, a two-step analytical method for quantifying CNMs embedded in polymer composites was developed. This method consisted of polymer dissolution process using organic solvents followed by subsequent programmed thermal analysis (PTA). This quantification technique was applicable to CNTs with and without high metal impurities in a broad range of polymers. Various types of CNMs were coated on polyester fabric and the efficacy of coatings as flame retardant was evaluated. The oxygen content of CNMs emerged as a critical parameter impacting flame retardancy with higher oxygen content resulting in less FR efficacy. The most performant nanomaterials, multi-walled carbon nanotubes (MWCNTs) and amine functionalized multi-walled carbon nantoubes (NH2-MWCNT) showed similar FR properties to current flame retardants but at a 10 times lower mass mass loading and hence are promising alternatives that warrant further investigation. Chemical/physical modification of MWCNTs was conducted to produce well-dispersed MWCNT solutions without involving oxygen for uniform FR coating. The MWCNTs coating was studied to evaluate the durability of the coating and the impact on the efficacy during use phase by conducting mechanical abrasion and washing test. Approximately 50% and 40% of MWCNTs were released from 1 set of mechanical abrasion and washing test respectively. The losses during simulated usage impacted the flame retardancy negatively.

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