Thermo-Oxidative Stability Study of Polypropylene Composites by Using Cone Calorimetry and Thermogravimetry

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The flammability of polypropylene (PP) and recycled PP composite systems was thoroughly investigated by using cone calorimetry and thermogravimetry techniques in order to quantify the effect of brominated and chlorinated fire-retardant systems. In this study, the efficiency of the fire-retarding systems was defined from the relation between the amount of fire retardants and the characteristic quantities in cone calorimetry (M-HRR, THR, and M-EHC) and the limited oxygen index. The brominated fire retardants showed fire-retarding capability superior to that of the chlorinated system, and the recycled polymer was thermo-oxidatively stabler than the pristine PP systems seemingly because of the fillers and blended polymers. Comparing the degradation behaviors of the composite systems in nitrogen and air environments, the halogen compounds retarded the decomposition rates in both cases, deactivating the reactive radicals of the polymer and restricting the flammable gases from being diffused into the unreacted polymer. Overall, the optimal amounts of fire retardants in different polymeric systems could be evaluated and correlated with several fire indicators in a relatively simple manner.

INTRODUCTION

Thermoplastic composites have various benefits including good processability, excellent mechanical properties, easy maintenance and repair, and recycling capabilities. Especially, polypropylene (PP) and its composites have been used in many applications in such areas as automobiles, electric/electronics, furniture, construction/architecture, interiors, insulation, etc. (1). As the use of polypropylene increases, the flammability and smoke emission problems associated with polypropylene become of practical importance. Broadening the applicability of polypropylene composites, it is necessary to improve its fire and smoke resistance by using appropriate quantities of fire retardants and fillers in a controlled manner (2).

Currently, halogenated compounds are the most efficient and cost-effective fire retardants for PP. However, halogen compounds have been criticized by environmental groups, such as Blue Angel in Germany, since the mid-1980s. Brominated fire retardants are in the center of the controversy. In fact, the problem is not their chemical nature during utilization, but rather, toxicology and environmental disruption that may be caused by the decomposed gases of the fire retardants during a fire. Those problems have been scientifically reviewed by various organizations. According to recent reports from EU, OECD, and WHO, brominated fire retardants may have positive aspects due to their short half-life and low accumulation in organisms (3–6). Although it may be argumentative, it should be mentioned that the risks of brominated compounds to the environment or human are highly uncertain, no chronic effects have been seen in the environment, and no significant human health effects have been clearly identified (6).

Economic aspects should also be considered in addition to these toxicology and environmental concerns. Considering the amounts of halogenated fire retardants used in resins such as ABS, HIPS, PE, PP, PBT, epoxy, and nylon, it may not be a simple issue to apply restrictions to the use of brominated fire retardants only for environmental protection. The cost of replacing halogenated flame retardants will be tremendous, and those uncertain risks may be made acceptable when the lives saved by the use of those flame retardants are considered (4). Flame retardants save lives and property by delaying ignition and flame spread. Flame-retarded products also provide a lower heat-release rate, which in turn lowers the quantities...