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Research on flame retardancy and Combustion Characteristics of PE and PE-MH-NC Cable Materials

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Abstract

In this paper, we have prepared three kinds cable materials based on the mixing of PE powders and $Mg(OH)_2$ powders. The pyrolysis process of PE, PE-MH and PE-MH-NC is analyzed by thermogravimetric experiment. The results of thermogravimetric experiment show that adding $Mg(OH)_2$ powers or the modified $Mg(OH)_2$ powders to PE can reduce the weight loss rate, and the percentage of residual mass of PE-MH and PE-MH-NC are 25.51% and 26.79%, while there are no residues after combusition of PE. The maximum heat release rate of PE-MH-NC decreases by 43.04% and the maximum smoke production rate of PE-MH-NC decreases by 11% than PE. The combustion characteristics of PE and PE-MH are analyzed by the cone calorimeter experiment. The results of cone calorimeter experiment show the maximum CO and CO2 production rate of PE-MH-NC decreases by 52% and 40.8%. It indicated that the effect of smoke suppressor about PE-MH-NC was remarkable through the cone calorimetry test, and its flame retardant performance was the best which satisfy many requirements of the flame retardant cable material.

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Keywords: Flame Retardant Cable, Pyrolysis kinetics, Combustion characteristic.

1. Introduction

In many electrical fires, most deaths are caused by inhalation of toxic and corrosive smoke generated when cable material is burning [1]. Therefore, the research of cable material with fire retardant and smoke suppression function is an important measure to prevent and reduce the occurrence of fire and reduce the loss of property and life. Magnesium hydroxide ($Mg(OH)_2$) is known as the "pollution-free flame retardant agent" due to advantages of non-toxicity, good thermal stability, low price and synergistic flame retardant effect with a variety of substances [2-4]. The main flame retarding mechanism of magnesium hydroxide is that magnesium hydroxide can release water vapor to dilute oxygen concentration of material surface in the thermal decomposition process, and at the same time it can absorb a lot of heat. So it can inhibit the temperature rise of the material surface, decrease the degradation rate of polymer and also reduce the generation of small combustible molecules [5-8].

In this paper, we use the supported $Mg(OH)_2$ powders which have absorbed thermochromic materials before as the flame retardant, and added it to the conventional cable material of polyethylene (PE) to produce a new cable material (PE-MH) with flame retardant property. At the same time, pure $Mg(OH)_2$ powders were reference. The ratio of PE and flame retardant in PE-MH is 6:4. The pyrolysis process of PE and PE-MH is analyzed by TG and the kinetics of pyrolysis is analyzed. The combustion characteristics of PE and PE-MH are analyzed by the cone calorimeter experiment.

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2. Experiment Section

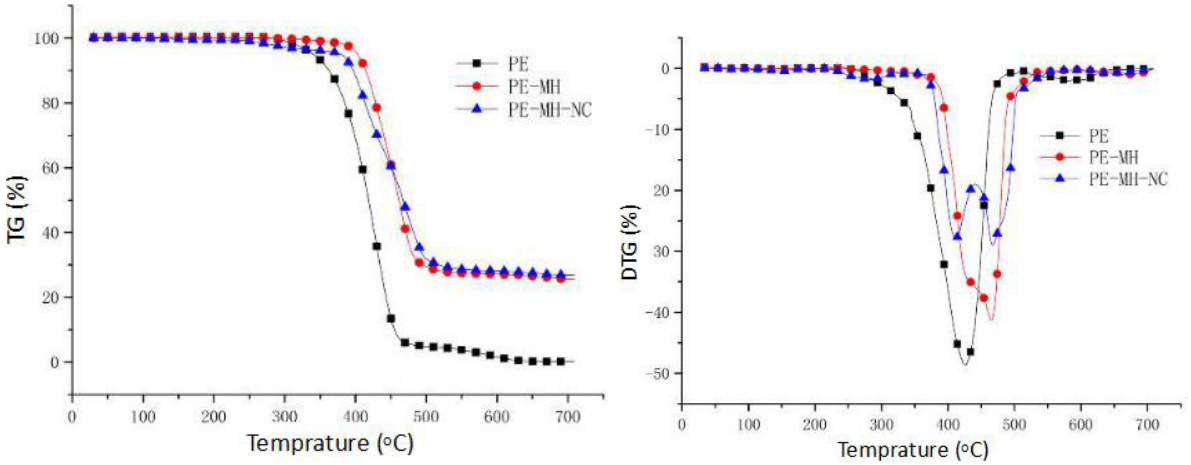
First, we have prepared two new cable materials which comprised with PE powers, $Mg(OH)_2$ powers and modified $Mg(OH)_2$ powers, they were named by PE-MH and PE-MH-NC cable material. The ratio of PE and $Mg(OH)_2$ in PE-MH is 6:4 and the ratio of PE and modified $Mg(OH)_2$ in PE-MH is 6:4. According to the ratio mixing PE powers and $Mg(OH)_2$ powders or modified $Mg(OH)_2$ powders, and adding the mixtures to the plastic molding machine to format PE-MH plastic broad. Besides, we also prepared pure PE plastic broad as reference.

Thermogravimetric analysis. To investigate the PE-MH material thermal stability, thermogravimetric analysis was employed for explaintion. The F1 TG209 type thermogravimetric analyzer of German Netzsch Corporation was adopted in the experiment. The temperature rose from room temperature to 700^{0}C. The gas atmosphere was air and the gas flow rate was 20mL/min. The heating rate was 40 ^{0}C/min.CONE tests. To determine heat release of tested material in oxygen consumption, CONE tests were adopted to analysis the heat release rate, smoke production rate, CO and CO_2 concentration. The FTT0007 type cone calorimeter of UK FTT Corporation was used in the cone experiment. The thermal radiation intensity of the experiment is 40kW.

3. Results and discussion

3.1. Thermogravimetric analysis

The TG and DTG curves of PE, PE-MH and PE-MH-NC are shown in Fig 1. From the TG curve of Figure 1-(a), we can know that PE has basically no residue left at 700^{0}C while the final residual mass of PE-MH is 25.51%. From the DTG curve of Figure 1-(b), we can know that PE and PE-MH-NC has two weight loss peaks, while PE-MH has only one weight loss peak. The pyrolysis temperature range of PE is as follows: the first stage is 379~455^{0}C, the second stage is 562~625^{0}C, While the pyrolysis temperature range of PE-MH-NC is as follows: the first stage is 383~425^{0}CThe pyrolysis temperature range of PE-MH is 412~483^{0}C.



(a) TG (b)DTG

Fig. 1 TG and DTG curve of PE,PE-MH and PE-MH-NC

Table. 1 Pyrolysis details of PE, PE-MH and PE-MH-NC

Sample	Stage	Temperature Range (^{0}C)	Weight Loss Range (%)	Max Weight Loss Rate (%/min)	Temperature of Max Weight Loss Rate (^{0}C)	Residual Mass (%)
PE	Ⅰ	379~455	83.79~10.61	48.58	427	No residues
	Ⅱ	562~625	3.33~0.65	1.91	593	
PE-MH	Ⅰ	412~483	91.29~32.22	41.19	410	25.51
PE-MH -NC	Ⅰ	383~425	94.48~72.89	27.77	412	26.79
	Ⅱ	458~498	56.11~32.11	28.85	467	