



Advanced Materials and Engineering

Edited by
Taufiq Yap Yun Hin



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Advanced Materials and Engineering

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Edited by

Taufiq Yap Yun Hin



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Preface

In order to be organized as a leading annual international conference of IAMR for researchers, scientists to participate all over the world, Annual International Conference on Intelligent Materials and Nanomaterials (AIMN14) is successfully held on April 18-19, 2014 in Seoul, South Korea.

AIMN14 serves as the important and influential platform for authors to publish manuscripts in excellent international proceedings and exchange new ideas face to face. AIMN14 is the unique conference with its strong organization team, dependable reputation and wide sponsors all around the world.

All accepted papers of AIMN14 have been strictly selected for the quality and the relevance to the conference. We sincerely hope that the current selected papers provide a good overview of the research activities related to advanced materials and engineering. These new materials includes, intelligent materials, nanomaterials synthesis and properties, nano devices and system, nano materials, technologies for applications, materials/nanufacturing processes, etc.

The volume of AIMN14 is expected to boast future research activities within the new actions, meetings and conferences and this volume is provided not only for the readers abroad overview of the latest research results on material science and related fields, but also for those who wish to have a valuable summary and reference in these fields.

We would like to express our sincere appreciations to all the authors for their contributions to this volume. We are indebted to all the referees for their constructive comments on the papers. Many thanks are also warmly given to Trans Tech Publications, the distinguished publisher of AIMN14.

All staffs of AIMN14 Organizing Committees from IAMR look forward to your continuous attention and support to this Annual International Conference in the future.

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CHAPTER 1:

Advanced Materials, Technologies and Applications

Gangue as Flame Retardants for Flexible Poly (Vinyl Chloride) ¹

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Key words: Gangue, flame retardant, aluminum hydroxide, PVC

Abstract: Gangue as flame retardant was used to PVC, the mechanical properties and flame retardance of the samples were studied. The resultant data show that gangue little effect on the mechanical properties of the sample, especially tensile strength, yield stress, and 10% of gangue obtained good flame retardance. PVC treated with flame-retardants showed a high limiting oxygen index, char yield, which indicated that the flame retardance of the treated PVC was improved.

Introduction

PVC materials or products tend to have excellent fire performance. But to make it easy to process, semirigid and flexible PVC compound always contains a large volume of plasticizer such as DOP [di(2-ethylhexyl)phthalate], which can deteriorate the flame retardation and smoke suppression properties. When the PVC products contain 45 parts DOP, the limiting oxygen index (LOI) would decrease to about 24 and the PVC would thus become a high-flammability material. However, plasticized PVC products can still have good fire performance, particularly if additionally fire-retarded [1,2].

In recent years, the use of metal hydroxide flame retardant and smoke suppressant in PVC has been reported [3,4]. These flame-retardants, e.g., $Mg(OH)_2$, $Al(OH)_3$ are required at high concentrations (40–60%) for imparting a good degree of flame retardancy. Because of the high loading it is essential that good degree of flame retardancy be obtained, but mechanical properties decrease obviously. Using coupling agents and synergists are good ways to solving this problem [5–7]. Many elements, such as alloys, organic substances and inorganic compounds including antimony, tin, zinc, copper, iron and molybdenum, have been used in the flame retardation and smoke suppression of PVC. Gangue contains many kinds of metal oxides, which may have the similar effective.

The purpose of our present study is to study mechanical properties, flame retardant of the samples treated with combinations of $Al(OH)_3$ and gangue.

Experimental

Materials

PVC, S G Type 2, dioctyl phthalate (DOP); Tribasic lead sulfate, Dibasic lead phosphate, commercially available; Stearic acid, industrial grade; $Mg(OH)_2$, industrial grade; $Al(OH)_3$, ZX-131 type.

Instrumentation

LOI values were determined in accordance with ASTM D2863-70 by means of a General Model HC-1 LOI apparatus. The vertical burning test was conducted by a CZF-II horizontal and vertical burning tester (Jiang Ning Analysis Instrument Company, China). The mechanical properties were

tested according to GB/T 1040.2-2006 standard with a LJ-5000 tensile testing machine (Chengde Experimental Factory).

Preparation of Flame Retardant PVC Samples

Formulation according to predetermined material (including PVC, three salts, salts of stearic acid, DOP, hydroxide, chloride, coal) are mixed in a mixer 3 to 5 minutes at 35 - 45 °C. Then the mixture was plastified on the two-roll mill at 165°C for 6-8 min, compressed at 180°C to form sheets of 100mm×10mm×3mm. The test specimens were cut from the molded sheets.

Table 1 The composition of the samples

Sample	PVC (g)	DOP (g)	Tribasic lead sulfate (g)	Dibasic lead phosphate (g)	Stearic acid (g)	Al(OH) ₃ (g)	Gangue (g)	Oxygen index (%)
A	500.0	150.0	7.5	7.5	5.0	0.0	0.0	24.5
B	500.0	150.0	7.5	7.5	5.0	5 0.0	0.0	26.6
C	500.0	150.0	7.5	7.5	5.0	75.0	0.0	28.4
D	500.0	150.0	7.5	7.5	5.0	100.0	0.0	29.5
E	500.0	150.0	7.5	7.5	5.0	125.0	0.0	29.4
F	500.0	150.0	7.5	7.5	5.0	125.0	5.0	29.7
G	500.0	150.0	7.5	7.5	5.0	125.0	10.0	29.8
H	500.0	150.0	7.5	7.5	5.0	125.0	15.0	29.2
I	500.0	150.0	7.5	7.5	5.0	125.0	20.0	27.9

RESULTS AND DISCUSSION

Flame retardancy of Al(OH)₃ and gangue

Al(OH)₃ as one halogen-free, flame-retardant additives, inorganic acid, used in plastics and rubber industry, attracted widespread attention. From the oxygen index values in Table 1, the flexible PVC added Al(OH)₃ has good flame retardancy, whose LOI increase from 24.5% to 29.4%. The flame-retardant effect of Al(OH)₃ in soft PVC is mainly based on their dehydration endothermic effect, thus inhibiting soft PVC temperature from rising. When addition of Al(OH)₃ reaches 100g, the best effect is obtained.

To get better flame retardancy for PVC, gangue was added. The data were shown in Table 1, LOI of samples (F,G) increase with the addition of gangue. When more gangue was added, the LOI of samples decrease, 10g gangue is optimal. Gangue and Al (OH)₃ can be a good flame retardant for flexible PVC.

Effect of Al(OH)₃ and gangue on the Mechanical Properties

Mechanical properties such as tensile strength, breaking strain, yield stress and tensile modulus of samples were measured, and shown in Figs.1-4.

Fig.1 shows the effect of the gangue on tensile strain of samples (TS), which shows that the TS increase when the added gangue's weight is less than 5g, when it is more than 5g and less than 10g, the TS decrease. When it is more than 10g and less than 15g, the TS second increase but slowly, while more than 15g, the TS decrease.

Fig.2 shows the effect of the gangue on breaking strain of samples (BS). We can see that the BS increase when the added gangue's weight is less than 7g, the BS start decreasing when the weight is more than 7g. Obviously, the highest value of BS is obtained when the gangue's weight is 7g.