

Preliminary study on decanoic/palmitic eutectic mixture modified silica fume geopolymer-based coating for flame retardant plywood

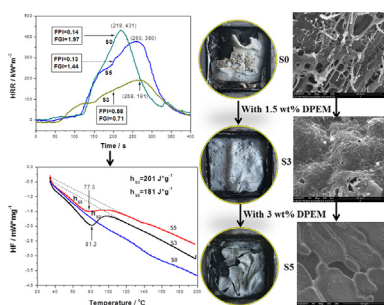
YaChao Wang^{*}, JiangPing Zhao

College of Materials & Mineral Resources, Xi'an University of Architecture & Technology, Xi'an 710055, PR China

HIGHLIGHTS

- Decanoic/palmitic eutectic mixture favors an enhancement of flame retardancy.
- Appropriate dosage exerts the highest flame retardancy.
- Continuous and intact siliceous layer imparts the enhancement.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:

Received 28 March 2018
Received in revised form 1 August 2018
Accepted 30 August 2018

Keywords:

Flame retardant coating
Fatty acid eutectic mixture
Cone calorimeter
Geopolymer

ABSTRACT

A facile preparation of decanoic/palmitic eutectic mixture (DPDM) modified silica fume geopolymer-based hybrid coating was preliminarily studied, the effect of DPDM on its flame retardancy and microstructure was characterized by techniques including cone calorimeter (CC), TG, and SEM-EDS. The experimental results showed that the appropriate dosage of decanoic/palmitic (1:1, wt%) fatty acid was equal to 1.5 wt%, which was beneficial to form a uniform and continuous barrier layer, leading to an enhancement of flame retardant efficiency, evidenced by the result that the fire performance index (FPI) climbed from 0.14 to 0.58 s·m²·kW⁻¹ and fire growth index (FGI) decreased from 1.97 to 0.71 kW·m⁻²·s⁻¹. It determined that the incorporation of DPDM into silica fume geopolymer-based coating was an effective method to prepare an efficient and eco-friendly flame-retardant coating.

© 2018 Elsevier Ltd. All rights reserved.

1. Introduction

Halogen-containing or phosphorous flame retardant coatings, predominantly fireproof techniques, generate pressing and persistent environmental issues with increasing global concern on the release of toxic gas and hardly harmless dispose. Hence, besides reducing flammability, current trend in developing a novel coating is aiming to fulfill multiple demands such as good thermal stability, smoke-suppressing, low toxicity, environmental conservation, and so on [1,2]. Consequently, halogen-free organic-inorganic

hybrid coating has become imperative to enhance its flame resistance. Generally, organic polyester is employed as the binder with inorganic material as the filler, and transition metal catalysis is an effective way to eliminate volatile organic compounds and toxic gases during combustion process [3–5]. Among inorganic fillers, the silica particles have been received considerable attentions due to its well-defined ordered structure, high surface area, cost-effective production, and the ease surface modification [6], which enlightens us on preparing cost-effectively inorganic silica composite to enhance its fire-resistant property. Accordingly, alkali-activated geopolymer, novel amorphous silicate derived from industrial solid waste, could be served as fireproof coating through cross-linking, filling, and bonding [7], the transition metal oxides

^{*} Corresponding author at: Yanta Road 13#, Xi'an 710055, PR China.

E-mail address: wangyachao@xauat.edu.cn (Y. Wang).

Table 1
Chemical composition of silica fume.

Raw materials	Mass percent (wt%)									
	CaO	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MgO	Na ₂ O	K ₂ O	SO ₃	TiO ₂	Loss
Silica fume	0.60	87.18	6.89	1.18	0.45	0.28	0.66	0.32	—	2.11

Table 2
Coating sample and its ingredient.

Samples	H ₂ O/g	Silica fume/g	Na ₂ SiO ₃ ·9H ₂ O/g	KOH/g	PAM/g	PDMS/g	EG/g	DPEM/g
Sr	0	0	0	0	0	0	0	0
S0	41.9	50.0	14.2	2.8	1.1	1.6	2.2	0
S1	41.9	50.0	14.2	2.8	1.1	1.6	2.2	0.57
S2	41.9	50.0	14.2	2.8	1.1	1.6	2.2	1.14
S3	41.9	50.0	14.2	2.8	1.1	1.6	2.2	1.71
S4	41.9	50.0	14.2	2.8	1.1	1.6	2.2	2.28
S5	41.9	50.0	14.2	2.8	1.1	1.6	2.2	3.42

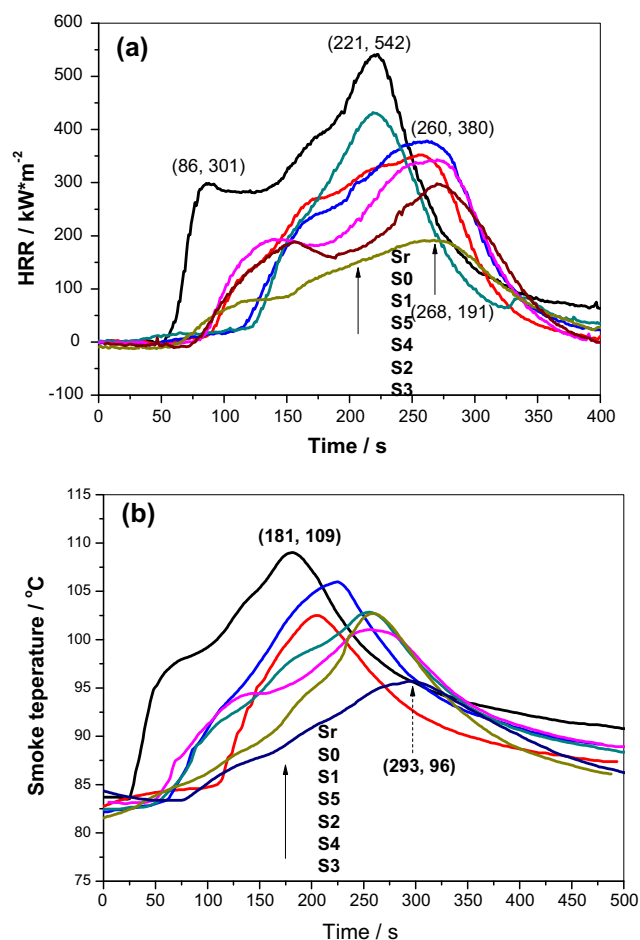


Fig. 1. HRR performance of samples.

involved in industrial solid waste hold catalytic effect on charring [3–5,8], constitutes a promising future due to its ecological nature and effective cost, which will attract the increasing attentions for research and applications.

Furthermore, our previous study has suggested a facile preparation of silica fume geopolymer-based flame-retardant coating [9], and the alkali-activated silica fume geopolymer served as binder has still not been documented considerably, because the main drawback identified for the geopolymer-based coating is its inferior flame retardant efficiency to carbonaceous coating. Given this

Table 3
Combustion characteristics tested by CC.

Samples	TTI/s	T _p /s	pHRR/ kW·m ⁻²	FPI/ s·m ² ·kW ⁻¹	FGI/ kW·m ⁻² ·s ⁻¹
Sr	18 ± 1	221 ± 1	542 ± 16	0.03	2.45
S0	62 ± 1	219 ± 1	431 ± 13	0.14	1.97
S1	83 ± 1	258 ± 1	355 ± 11	0.23	1.38
S2	96 ± 1	272 ± 1	297 ± 9	0.32	1.09
S3	110 ± 1	268 ± 1	191 ± 6	0.58	0.71
S4	55 ± 1	263 ± 1	343 ± 10	0.16	1.30
S5	49 ± 1	262 ± 1	378 ± 12	0.13	1.44

opportunity, phase change material (PCM), as a potential technique to reduce energy demand in buildings [10], has also been used to prepare halogen-free flame retardants [11–13].

Additively, polynary fatty acid eutectic mixture, as a kind of solid-liquid PCMs, has been devised and applied in building energy conservation [14–17]. Unfortunately, little in-depth and comprehensive investigation has been focused on the effect of decanoic/palmitic eutectic mixture (DPEM) on fireproof performance of geopolymer-based coating. Consequently, this study scrutinizes the influence of DPEM on the flame retardancy of silica fume geopolymer-based coating, which was tested by cone calorimeter (CC) using plywood as substrate, its microstructure was characterized by techniques including scanning electron microscope-energy dispersive spectrometer (SEM-EDS), and thermal gravimetry (TG). It is anticipated to explore an efficient and eco-friendly flame-retardant coating, which possesses enhanced flame resistance and ecological features simultaneously.

2. Experiment and methods

2.1. Preparation of silica fume geopolymer-based coating

2.1.1. Raw materials

Silica fume, a kind of grey powders, was collected from Linyuan Co. of Xi'an in ShaanXi province with a density of 1.62 g·cm⁻³ and Blaine specific surface area of 25 m²·g⁻¹, the content of SiO₂ analyzed by X-ray fluorescence (XRF) was 87.18% as shown in Table 1. Chemical activators, analytically pure Na₂SiO₃·9H₂O and KOH, were produced in HongYan reagent factory of Tianjin. DPEM was synthesized by ultrasonic dispersion of the molten decanoic and palmitic under 80 °C with a decanoic/palmitic weight ratio of 1:1, and its melting point decreased to 27.2 °C, decanoic and palmitic acid were purchased from FuChen reagent factory of Tianjin. Polydimethylsiloxane (PDMS), as the modifier to improve the water resistance, was purchased from Xiameter (R) PMX-200 with a viscosity of 350 mm²·s⁻¹. Polyacrylamide (PAM), served as the thickener and film-forming agent, was produced by the reagent factory of Shanghai. Expandable graphite (EG), as the charring agent to improve flame retardancy, was obtained from Qingdao chemical group with an expansion rate of 300 mL·g⁻¹ and an average size of 48 μm. The plywood was purchased from timber processing plant of Xi'an with second-class flame retardancy.

Download English Version:

<https://daneshyari.com/en/article/8959991>

Download Persian Version:

<https://daneshyari.com/article/8959991>

[Daneshyari.com](https://daneshyari.com)