# INFLUENCE OF FOUR COATINGS ON THE MOLD-RESISTANCE AND COMBUSTION PERFORMANCE OF DECORATIVE BAMBOO CURTAIN


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**Abstract.** Decorative bamboo curtain (DBC) is a kind of bamboo product made of bamboo filaments by weaving or applying adhesive, and is becoming popular as an interior decorative material with a disadvantage of mildew. In this study, four antimold coatings, including wax oil (WO), polyurethane varnish (PV), silicone acrylic emulsion (SE), and SE with 3-iodo-2-propynyl butylcarbamate (SI), were applied to improve the antimildew capability of DBC. The resistance to mold fungi performance was evaluated using the Chinese National Standard GB/T 18261-2013, and combustion performance of DBC was analyzed by cone calorimetry. The results showed that the SI coating group had the best antimildew performance with an efficacy of 100%. SE and PV coatings had the worst performance. The antimildew performance of the WO coating was almost the same as that of the PV coating. External thermal radiation, composition of pyrolysis, and pyrolysis rate of the antimold coatings and DBC were completely different. During the combustion process, all coated groups showed a tendency to increase total heat release (THR). The THR of the WO and PV groups increased 22.22% and 13.33%, respectively; the THR of the SE and SI groups both increased by 4.44%. Total smoke production and specific extinction area values decreased slightly in the SE and SI groups, whereas those in the WO and PV groups showed an increasing trend. The SI group was very suitable to be used as antimold coatings on the surface of DBCs because of its best antimildew performance and smoke suppression.

***Keywords:*** Decorative bamboo curtain, antimold coating, preventing efficiency, combustion performance.

## INTRODUCTION

Bamboo is an environmentally protected and sustainable material used in buildings and for interior decoration. It has become a popular material in the current architectural decoration industry with its elegant appearance, high plasticity, flexibility, durability, and economic value (Li et al 2016a). However, because of the high sugar, protein, and starch contents, it is vulnerable to fungi, insects, and other organisms (Wu et al 2017), particularly during storage, transportation, and manufacturing, which results in the loss of bamboo (Liese 2003; Liu et al 2015). Therefore, mold-resistance research is very important to expand the application range of bamboo products and to increase their economic value.

Decorative bamboo curtain is a kind of bamboo product woven with parallel bamboo filaments. Because of its excellent environmental performance, appearance, plasticity, and convenient installation and removal, decorative bamboo curtains are becoming popular as an interior decoration material that can substitute for traditional wallpaper or paint (Yu et al 2015). Decorative bamboo curtains are also prone to mildew during application (Li et al 2018a). However, research on antimildew and antidiscoloration technology for decorative bamboo curtains has rarely been reported but is necessary for further applications.

Few studies have been conducted on antimildew processes for bamboo products. Heat and ultrasonic treatments have been reported to prevent mold in bamboo, but their effects are limited (Chu 2013; Guan et al 2013; Yu et al 2014; Zhou et al 2017). Chemical treatments are the most effective methods to improve mold-resistance performance (Li et al 2016b; Su et al 2016; Song et al 2017; Zhang et al 2017). However, many chemical agents, especially those added using the immersion method, can deform the bamboo structural units. Therefore, heat and chemical treatments with a water-soluble antimildew agent are not as effective as treatment with an antimildew modifier for protecting decorative bamboo curtains. Antimildew agents can be added to bamboo products during pretreatment, intermediate treatment, and posttreatment, and the posttreatment method is presumed to be the best method for decorative bamboo curtains. The reason is that the pretreatment and intermediate treatment supplement the corresponding processes of drying and screening, which makes the existing processes more complex and reduces production efficiency. Thus, an antimildew coating without a water-based mold inhibitor added during postprocessing should be the most appropriate treatment process for decorative bamboo curtains.

Furthermore, bamboo contains higher comprehensive cellulose and lower lignin and extract, which are easier to burn violently and release a lot of smoke. The combustion of bamboo is a rather complicated process, which has both physical and chemical reactions. In the preheating stage, the water in the bamboo is evaporated. As the temperature of the bamboo surface and interior increases, the chemical components begin to pyrolyze and then produce combustible gases. Subsequently, the bamboo burns and releases a lot of heat and flame once the temperature reaches the point of ignition (Haensel et al 2009; Mehrotra et al 2010; Qu et al 2010). Nevertheless, the units of decorative bamboo filament are thinner, smaller, and more flammable. According to the compulsory Chinese national standards GB/T 20286 (2006) and GB/T 8624 (2012) issued by the Fire Department of the Chinese Ministry of public security, construction and indoor decoration materials must be tested before they can be used (Yu et al 2017; Li et al 2018b). Therefore, the combustion performance test of decorative bamboo curtains is necessary for fire safety assessment.

In this study, four kinds of coating agents were selected and tested for mold resistance. Furthermore, the combustion performance of decorative bamboo curtains before and after coating was measured by a cone calorimeter.

## MATERIALS AND METHODS

### Materials

Six-year-old Moso bamboo (*Phyllostachys edulis* (Carr.) J. Houz) was obtained from Anji, Zhejiang Province, China, with a MC of 7% after air-drying. Its diameter at breast height was 140-160 mm with a wall thickness of 12-16 mm. The bamboo filaments were drawn from the bamboo splits located on the outboard bamboo skin in the radial direction using a drawing machine (Fig 1).

The size of a single bamboo filament was 5 mm (tangential) × 1000 mm (longitudinal) × 2 mm (radial). The bamboo filaments were made into a decorative bamboo curtain using chemical fiber wire. The bamboo curtain was cut into small samples with dimensions of 100 mm (tangential) × 100 mm (longitudinal) × 2 mm (radial). One group was considered the control (C) group and the other groups were coated with the mildew proofing coatings listed in Table 1. Ten replicates were used for each treatment.

Four coating groups were compared: wax oil (WO), polyurethane varnish (PV), silicone-selected acrylic emulsion (SE), and SE with 3-iodo-2-propynyl butylcarbamate (IPBC) (SI) were selected as the surface finishing agents. The first three are widely used in the market currently and the last coating had a fungicide added to the SE group. WO and PV can be manually painted on the bamboo curtain with a brush. The silicone acrylic emulsion with a mass fraction of 50.2% was diluted in water and used as a coating for the SE group with a mass fraction of 20%. In the SI

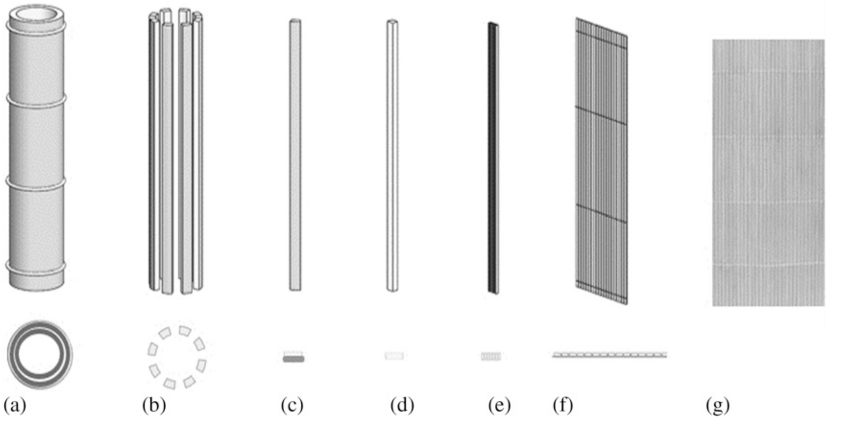


Figure 1. Decorative bamboo curtain manufacturing process. (a) Bamboo tube; (b) bamboo strips; (c) bamboo strips after screening; (d) bamboo strips after finishing planing; (e) bamboo filaments; (f) decorative bamboo curtain; (g) photograph of an actual decorative bamboo curtain.

Table 1. The main components of the different coatings.

| Sample label | Component | Source | Replicates |
|---|---|---|---|
| C | — | — | 10 |
| WO | Wax oil | Purchased | |
| PV | Polyurethane varnish | Purchased | |
| SE | Silicone acrylic emulsion | Made in this study | |
| SI | Silicone acrylic emulsion with 3-iodo-2-propynyl butylcarbamate | Made in this study | |

group, IPBC, with a purity of 80%, was dissolved in ethanol at a ratio of 1:20 (g:mL), followed by mixing with the silicone acrylic emulsion from the SE group. The mold-resistance coating prepared for the SI group had an IPBC content of 1.5% (the mass fraction). The SI solution was stored in a brown reagent bottle to prevent photodegradation of the IPBC. The coating amount of each group was 120-150 g/m$^2$. After coating, all specimens were placed indoors (25 ± 2°C and RH of 50%) for 10 d to ensure that they were air-dry. The three kinds of mold fungi products applied in the laboratory mold-resistance tests are listed in Table 2.

## Mold-Resistance Test

All specimens were placed at a temperature of 28 ± 2°C and RH of 85% for 28 d to observe fungal growth on the surfaces. The specimens were processed into 50 mm (longitudinal) × 20 mm (width) × 2 mm (thickness) strips according to GB/T (2013). After inoculating the target fungi, fungal growth was estimated visually using a score scale of 0-4 (Table 3).

The efficiency of mold resistance (*E*) was calculated as follows:

$$E = \left(1 - \frac{D_t}{D_0}\right) \times 100\%, \quad (1)$$

where $D_t$ is the average infection value of the treated samples and $D_0$ is the average infection value of the untreated control samples.

Table 2. Types and sources of fungi in the resistance assessment.

| Fungi | Source | Replicates |
|---|---|---|
| *Trichoderma viride* | Chinese Academy of Forestry | 6 |
| *Penicillium citrinum* | | |
| *Aspergillus niger* | | |

## Combustion Performance Evaluated Using Cone Calorimeter

The combustion performance of the specimens was tested with a cone calorimeter (FTT0242; Fire Testing Technology Co. Ltd., West Sussex, UK) according to ISO (2002). Six specimens from each group were selected and placed horizontally under the cone calorimeter with a heat flux of 50 KW/m$^2$. A stainless steel cover with an opening of 0.0088 m$^2$ on the upper part was attached. Data were recorded by a computer every 5 s. The main comparative parameters included heat release rate (HRR), total heat released (THR), and total smoke released.

# RESULTS AND DISCUSSION

## Mold Resistance

Mold is mainly spread by spores in the air, so the route of infection became established once the mold attached to the bamboo. The factors affecting this process include temperature, humidity, oxygen, and the MC of the bamboo (Zhang et al 2015). Furthermore, bamboo contains more organic substances than wood, including 1.5-1.6% protein,

Table 3. Ranking system for specimen mold damage.

| Infection value | Infection area of the specimen |
|---|---|
| 0 | No mycelium on the surface |
| 1 | Sample surface area of less than 1/4 |
| 2 | Surface area of sample 1/4-1/2 |
| 3 | Surface area of sample 1/2-3/4 |
| 4 | Sample surface area more than 3/4 |

2% sugar, 2.0-6.0% starch, and 2.0-4.0% fat and wax (Wu 1992). When bamboo is placed under high moisture and heat, the nonstructural carbohydrates provide essential nutrients and a growth environment for mold reproduction, especially in the vascular bundles, vessels, tracheids, and pits of parenchyma cells where mildew grows easily (Schmidt et al 2011; Tang et al 2012; Zhao et al 2014a).

The samples were placed in Petri dishes with different molds (Table 2). During the test period, the speed of mildew growth and mold rate rose rapidly during the first week but increased more slowly from the second to the third week. The mycelia of *Trichoderma viride* (*Tv*), *Penicillium citrinum* (*Pc*), and *Aspergillus niger* (*An*) climbed onto the C group on days 4, 6, and 3, respectively. All groups (except the SI group which had no observed mold on the surface until the end of the testing) are shown in Fig 2.

According to Fig 2, the initial mildew time of the coated groups (including PV, WO, and SE) all lagged behind the C group, which might be attributed to different MC caused by the surface coating. Moisture was blocked in the decorative bamboo curtain by the coating at the beginning of the test cycle. However, the antimildew coatings did not absolutely separate the decorative bamboo curtain from the air and moisture gradually entered the sample, which was the main reason for the initial time delay in the mildew. Furthermore, the hyphae of *An* originally appeared earlier than those of *Tv* and *Pc*, which may have been due to the better environmental adaptability of *An*.

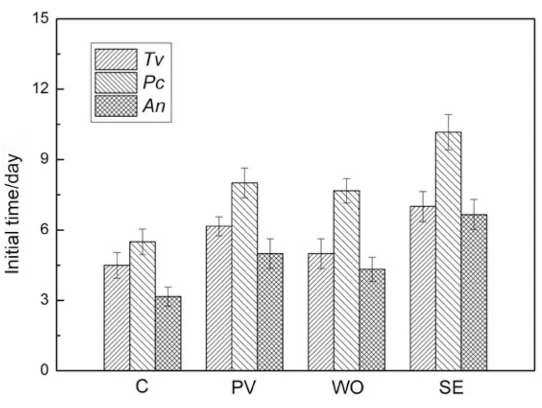


Figure 2. The initial and completely covering time of mildew before and after coating. C, control; PV, polyurethane varnish; WO, wax oil; SE, silicone acrylic emulsion; *Tv*, *Trichoderma viride*; *Pc*, *Penicillium citrinum*; *An*, *Aspergillus niger*.

The growth of mycelia was observed carefully during testing to assess the antimold performance of the mildew proofing coatings. The mold-resistance capability of the uncoated and coated decorative bamboo curtains is shown in Table 4 and the photographs shown in Fig 3 were taken on day 28. The one-way analysis of variance for the coated decorative bamboo filament with different coatings is shown in Table 5. It was noted that different groups had significant effects on the three mold growth scale. The results indicated that decorative bamboo filament with seasonable coating was necessary for its antimold performance.

Four weeks after inoculating each specimen, the mildew on the C group surface was significant, with a damage value of four, indicating that the decorative bamboo curtain had no resistance to mold. The mold-resistance capability of the coated samples increased to different extents compared with that of the C group. The efficiency to prevent the growth of *Tv* and *Pc* improved slightly in the WO and PV groups, but not for *An*. This observation indicated that WO and PV had a barrier effect on infection by *Tv* and *Pc*, which was only a physical barrier, but had no effect on *An*. The efficiency to prevent growth of the SE group was higher than that of the other two groups, particularly in preventing the growth of *Pc*. However, the SI group had no mildew until the end of the test cycle, and the efficiency to prevent mold growth reached 100%. These results reveal that the SI coating significantly improved the antimildew performance of the decorative bamboo curtain, which was likely because of the effects of multiple factors. First, the SI coating blocked moisture from entering the bamboo, as it formed a polymer film that isolated moisture and mold, so the bamboo surface maintained a sterile environment that avoided mold (Zhang et al 2013). By contrast, IPBC,

Table 4. Mold growth scale of the decorative bamboo curtain with different coatings.

| | Mold growth scale | | | | | | Mold preventing efficiency (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Tv* | SD | *Pc* | SD | *An* | SD | *Tv* | SD | *Pc* | SD | *An* | SD |
| C | 4 | 0 | 4 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| WO | 3.83 | 0.41 | 3.66 | 0.52 | 4 | 0 | 4.17 | 10.2 | 8.33 | 12.9 | 0 | 0 |
| PV | 3.83 | 0.41 | 3.33 | 0.52 | 4 | 0 | 4.17 | 10.2 | 16.67 | 12.9 | 0 | 0 |
| SE | 2.67 | 0.52 | 1.50 | 0.55 | 2.83 | 0.41 | 33.33 | 12.9 | 62.5 | 13.7 | 29.17 | 10.2 |
| SI | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 100 | 0 | 100 | 0 |

C, control; PV, polyurethane varnish; WO, wax oil; SE, silicone acrylic emulsion; SI, silicone acrylic emulsion with 3-iodo-2-propynyl butylcarbamate; *Tv*, *Trichoderma viride*; *Pc*, *Penicillium citrinum*; *An*, *Aspergillus niger;* SD, standard deviation.

known as a broad-spectrum antibacterial agent, inhibits mold growth by inhibiting mitosis (Baileys et al 2003; Kositchaiyong et al 2014). The SI group showed the best antimildew effect because it was a physical cover and it biologically inhibited the mold.

## Combustion Performance Analysis

***Heat release analysis.*** HRR and THR are important evaluation indices that describe combustion performance (Fig 4). The values of the corresponding parameters are listed in Table 6.

It appeared from the HRR curves (Fig 4[a]) that the coatings promoted very rapid ignition of the sample, except in the SE group. After ignition, the presence of the coatings enhanced the HRR value. The curves of the five groups were similar during the first 15 s. The flame and glow of the WO, PV, and SI groups were vigorous and fast during the combustion process from 15 s to 60 s, whereas those of the C group were relatively

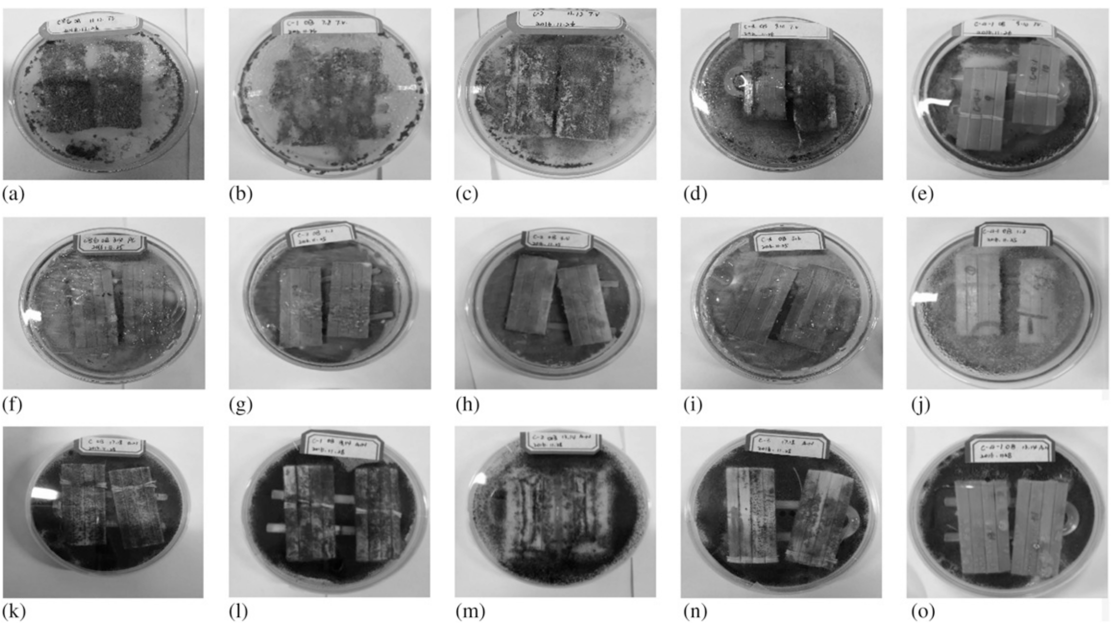

Figure 3. Photographs of samples after 28 da. (a) Control (C) group with *Trichoderma viride* (*Tv*); (b) wax oil (WO) group with *Tv*; (c) polyurethane varnish (PV) group with *Tv*; (d) silicone acrylic emulsion (SE) group with *Tv*; (e) SE with 3-iodo-2-propynyl butylcarbamate (SI) group with *Tv*; (f) C group with *Penicillium citrinum* (*Pc*); (g) WO group with *Pc*; (h) PV group with *Pc*; (i) SE group with *Pc*; (j) SI group with *Pc*; (k) C group with *Aspergillus niger* (*An*); (l) WO group with *An*; (m) PV group with *An*; (n) SE group with *An*; (o) SI group with *An*.

Table 5. One-way analysis of variance for mold growth scale of the decorative bamboo curtain by SPSS.

| | Quadratic sum | df | F | Significant |
|---|---|---|---|---|
| *Trichoderma viride* | 68.467 | 4 | 142.639 | 0.000 |
| *Penicillium citrinum* | 69.333 | 4 | 104.000 | 0.000 |
| *Aspergillus niger* | 72.133 | 4 | 541.000 | 0.000 |

df, degrees of freedom; F, f-measure.

slow. Different from the other coating groups, the ignition time of the SE group was delayed from 17 s to 22 s and the peak HRR time was also delayed correspondingly by 5 s (Table 6). All groups returned to a consistent trend after 60 s and released heat at a slow rate.

The THR for the decorative bamboo curtain with different coatings is shown in Fig 4(b) and

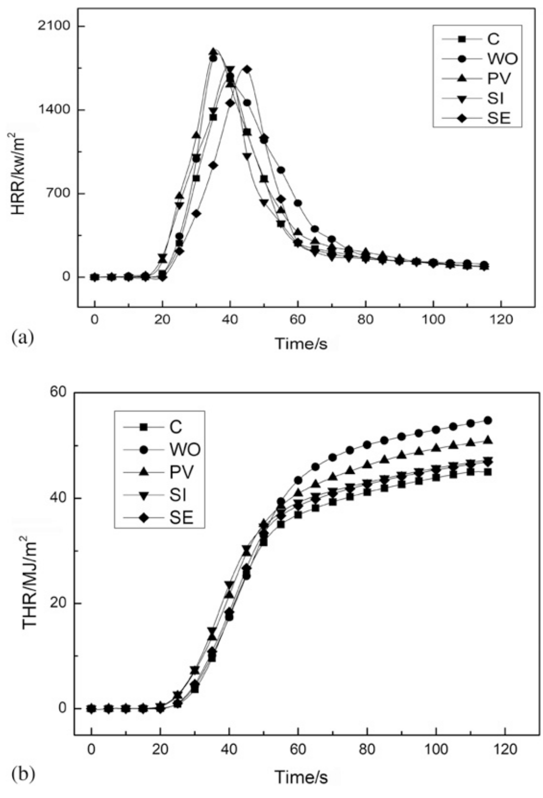


Figure 4. The heat release rate (HRR) (a) and total heat release (THR) (b) curves of decorative bamboo curtain with different coatings. C, control; PV, polyurethane varnish; WO, wax oil; SE, silicone acrylic emulsion; SI, silicone acrylic emulsion with 3-iodo-2-propynyl butylcarbamate.

Table 6. The THR value of the C group was lower than that of the coated groups, and the THR curves of the SE and SI groups were superimposed. The THR values of the WO and PV groups increased 22.22% and 13.33%, respectively, compared with that of the C group. However, the THR value of the SI and SE groups increased slightly by 4.44%. These results indicate that SI and SE had a minimal impact on heat release.

The one-way analysis of variance for the coated decorative bamboo filament with different coatings is shown in Table 7. It was noted that different groups had significant effects on the ignition time, peak time, THR, and peak value of heat release ($PK_{HRR}$).

All results were attributed to the chemical composition of the coatings. The main components of WO were vegetable oil and palm wax, and that of PV was polyurethane. The main components of SE and SI both were unsaturated silicone monomers and acrylic monomers. The difference between them was the existence of IPBC, which contributed little to heat release during the combustion process because of its very low proportion (mass fraction 1.5%), but IPBC had a positive role in preventing mold. The coating materials of the four groups were all macromolecular polymers that had completely different combustion performances. The three different stages during bamboo thermal degradation were dehydration, hemicellulose pyrolysis, and cellulose and lignin pyrolysis. Hemicellulose was easy to be degraded, and its pyrolysis was focused at 220-315°C. Pyrolysis of cellulose happened mainly at 315-400°C, whereas that of lignin covered a whole temperature range (150-900°C) (Yang et al 2007), and the pyrolytic products played a major role in combustion (Zhang et al 2016). PV is a highly flammable material with an oxygen index of only 16.5%. Its main component is polyurethane, which is a reaction product of polyisocyanates and polyhydric alcohols (Xu et al 2014; Wang et al 2017). Pyrolysis of PV in air is divided into three stages: the initial temperature was approximately 200°C, which was the evaporation stage for the adsorbed water; when

Table 6. Heat release and time of appearance of the different coatings.

| | Ignite time (s) | | Time to peak (s) | | THR T115 ($MJ/m^2$) | | $Peak_{HRR}$ ($KW/m^2$) | |
|---|---|---|---|---|---|---|---|---|
| Sample label | Mean value | SD | Mean value | SD | Mean value | SD | Mean value | SD |
| C | 17 | 1.77 | 40 | 1.41 | 45 | 2.04 | 1658 | 2.32 |
| WO | 14 | 1.26 | 35 | 1.41 | 55 | 2.28 | 1784 | 2.59 |
| PV | 12 | 1.41 | 35 | 1.79 | 51 | 1.79 | 1811 | 2.32 |
| SE | 22 | 1.79 | 45 | 2.00 | 47 | 1.94 | 1740 | 2.58 |
| SI | 15 | 1.83 | 40 | 1.90 | 47 | 2.10 | 1758 | 2.16 |

C, control; PV, polyurethane varnish; WO, wax oil; SE, silicone acrylic emulsion; SI, silicone acrylic emulsion with 3-iodo-2-propynyl butylcarbamate; $Peak_{HRR}$, peak value of heat release; THR, total heat release; SD, standard deviation.

the temperature rose to 200-630°C, the varnish began to burn; and combustion ended when the temperature exceeded 630°C (Li et al 2013). WO is a mixture of catalpa oil, linseed oil, suzi oil, pine oil, palm wax, plant resin, and natural pigments. The pyrolysis and combustion requirements of WO were lower than those of PV. That is, both the WO and PV coatings pyrolyzed before 250°C, and a large amount of combustible gases was released simultaneously, promoting the combustion of the decorative bamboo filament (Zhao et al 2014; Ye 2016). The ignition time of the WO and PV groups was advanced compared with that of the C group because of this combustion support.

Therefore, the heat released from combusting PV and WO accelerated pyrolysis and promoted sufficient combustion of the decorative bamboo curtain (Yan et al 2015), which was why the appearance time advanced and the $PK_{HRR}$ and THR increased in the WO and PV groups.

SE is a kind of emulsion containing organic silicon monomers with unsaturated bonds and acrylic monomers, which is prepared by nuclear shell coating polymerization (Hu 2014; Zong et al 2016). Organic silicone has excellent thermal oxidation stability and almost all flash points are >300°C, which is determined by the properties of the –C–Si– bond (molecular backbone for silicone acrylic emulsion) (Zhang et al 2005). The silicone acrylic emulsion and decorative bamboo curtain absorbed heat when the flame acted on specimens in the SE group. Some of the heat acted on the coating, whereas the other part of the heat was applied to pyrolyze the bamboo. Because the flash point temperature was higher than that of bamboo pyrolysis, the coating cut off the flammable gases released by pyrolysis of the bamboo. The ignition time was delayed and combustion was suppressed because of the oxygen isolated by the Si–O–Si–C inorganic layer. However, because of the ethanol contained in the SI group, the ignition and appearance times were advanced from those of the SE group.

***Smoke release analysis.*** Combustion of organic matter is accompanied by pyrolysis, dehydrogenation, and free radical reactions. Organic matter forms smoke when it is not fully burned. Studies have shown that smoke released in a fire is an important factor in death (Prabhakar et al 2015; Du et al 2017). In addition, smoke reduces visibility at the fire scene and delays rescue. Therefore, it is very important to suppress

Table 7. One-way analysis of variance for heat release–related parameters by SPSS.

| | Quadratic sum | df | F | Significant |
|---|---|---|---|---|
| Ignite time | 334.333 | 4 | 31.821 | 0.000 |
| Time to peak | 420.000 | 4 | 35.473 | 0.000 |
| Total heat release | 380.333 | 4 | 22.930 | 0.000 |
| $Peak_{HRR}$ | 80717.133 | 4 | 3507.407 | 0.000 |

$Peak_{HRR}$, peak value of heat release; df, degrees of freedom; F, f-measure.

Table 8. One-way analysis of variance for smoke release–related parameters by SPSS.

| | Quadratic sum | df | F | Significant |
|---|---|---|---|---|
| ASEA | 37511.980 | 4 | 914.523 | 0.000 |
| Average CO production | 0.001 | 4 | 48.011 | 0.000 |
| Average $CO_2$ production | 0.094 | 4 | 2.298 | 0.087 |
| Total smoke release | 4.295 | 4 | 243.170 | 0.000 |

df, degrees of freedom; F, f-measure.

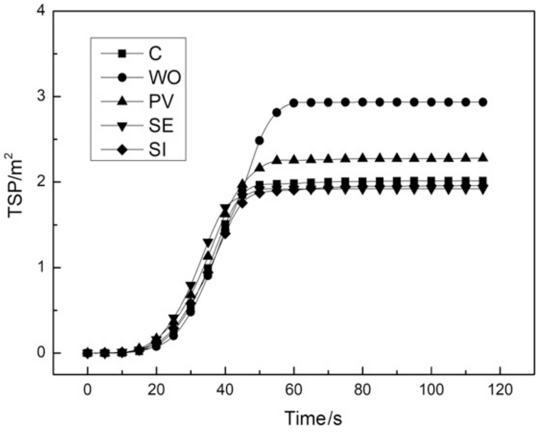


Figure 5. Smoke release curves of decorative bamboo curtain. C, control; PV, polyurethane varnish; WO, wax oil; SE, silicone acrylic emulsion; SI, SE with 3-iodo-2-propynyl butylcarbamate; TSP, total smoke released per unit.

the release of smoke and toxic gases generated during combustion. The total smoke released per unit (TSP) is a critical parameter for a fire retardant performance evaluation. The one-way analysis of variance for smoke release–related parameters by SPSS is shown in Table 8. It was noted that different groups had significant effects on ASEA, CO production, and total smoke release. The TSP curves of the specimens and correlation parameters during the combustion process are shown in Fig 5 and Table 9.

The TSP and ASEA increased markedly in the WO and PV groups, whereas they decreased in the SI and SE groups compared with the C group (Fig 5). The order of smoke production was WO > PV > C > SI > SE. The maximum TSP and ASEA in the WO group increased by 45.77% and 43.35%, respectively. The corresponding parameters in the PV group increased 13.43% and 16.53%. By contrast, the SI group TSP and ASEA decreased by 3.00% and 6.73% and those in the SE group decreased by 4.48% and 9.24%, respectively. Average CO production decreased in the SE and SI groups, but increased in the WO and PV groups. The variations in average $CO_2$ produced followed the same pattern as those of CO. The vegetable oil in the WO group contained unsaturated fatty acids and glycerin. The main gas products from the PV group were low molecular alkanes and olefins, which burn and produce CO and $CO_2$ easily (Li et al 2009; Zhao et al 2014). Therefore, the components of the coatings were the reason for the increased smoke.

As shown in Table 9, the SE and SI groups all had some smoke suppression performance, which was because of the expansibility of the silicone acrylic emulsion. When the silicone acrylic emulsion was exposed to fire, it generated not only a foam carbonaceous layer but also an Si–O–Si–C inorganic layer. The foam carbonaceous layer wrapped the smoke and prevented combustible gases from escaping during pyrolysis, whereas the Si-O-Si-C inorganic layer isolated the flame and oxygen to inhibit combustion, thereby reducing the amount of smoke released by the SE group (Lin and Wang 2012). The SI group had a slightly less effective smoke-suppressing effect compared with the SE group.

## CONCLUSIONS

1. WO and PV had little effect on inhibiting mold growth compared with the uncoated (C) sample. SE was slightly better than all of them. SI had the best mold-resistance performance, and its antimold efficacy reached 100%.

Table 9. Smoke release by the decorative bamboo curtain.

| Sample label | ASEA ($m^2 \cdot kg^{-1}$) | SD | Average CO production ($kg \cdot kg^{-1}$) | SD | Average $CO_2$ production ($kg \cdot kg^{-1}$) | SD | TSP T115 ($m^2$) | SD |
|---|---|---|---|---|---|---|---|---|
| C | 183.45 | 3.12 | 0.0760 | 0.03 | 3.3857 | 0.13 | 2.01 | 0.04 |
| WO | 262.97 | 4.33 | 0.0784 | 0.02 | 3.4408 | 0.07 | 2.93 | 0.07 |
| PV | 213.78 | 3.14 | 0.0806 | 0.02 | 3.4028 | 0.06 | 2.28 | 0.06 |
| SE | 168.5 | 2.52 | 0.0662 | 0.02 | 3.2805 | 0.11 | 1.92 | 0.08 |
| SI | 171.10 | 2.56 | 0.0684 | 0.02 | 3.3329 | 0.10 | 1.95 | 0.06 |

C, control; PV, polyurethane varnish; WO, wax oil; SE, silicone acrylic emulsion; SI, silicone acrylic emulsion with 3-iodo-2-propynyl butylcarbamate; TSP, total smoke released per unit; SD, standard deviation.

2. All of the coated groups showed a tendency to increase THR during combustion. The THR of the WO and PV groups increased 22.22% and 13.33%, respectively, and that of the SE and SI groups both increased by 4.44%.
3. The TSP and ASEA values decreased slightly in the SE and SI groups during the combustion process, whereas those in the WO and PV groups showed an increasing trend. The best smoke-suppressive effect was observed in the SE group. The TSP and ASEA values decreased 4.48% and 9.24%, respectively.
4. SI showed excellent mold-resistance performance and smoke-suppressive effect as anti-mold coatings used on the surface of decorative bamboo curtains.

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