A NOVEL COMPOSITE MATERIAL WITH FLAME RETARDANT AND ANTIBACTERIAL PROPERTIES IN INTERIOR SYSTEM

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ABSTRACT

To meet the special standards of interior systems in space station or high speed rail, a novel series of T700/602 prepregs with flame retardment and antibacterial properties were prepared by hot melt impregnation. In this study, their mechanical properties, production of combustion, flame retardment, antibacterial and mildew proof properties were systematicly studied to get the relationship between additives and properties. The concentration of composite faceplates' production of combustion (CO,HF,HCl,NO_x,SO_2,HCN) was far below the standard value. Meanwhile, it had the outstanding flame retardment property without any flame penetration and drippage of melt, since their self-extinguishment time were all 0s. We also found that the mildew proof level of all the samples was 0. Moreover, along with the concentration of additives increasing, antibacterial property became stronger while mechanical properties was weaker. When the concentration of antimicrobial additives was higher than 2%, it can meet the standard requirement.

1 INTRODUCTION

The functional modification of Composites can increase the applicability and diversity of the material so as to realize the integration of the structure and function. This research field is a hot spot in the latest research, including the integration of structure – damping[1], structured wave propagation[2], sound-absorbing structure[3], structure – heat insulation[4] and so on.

Recently, due to the combustibility of the composites themselves, we need to carefully choose indoor composite materials' flame retardant properties and combustion products in the space station and other interior systems[5-6]. Furthermore, in order to control the breeding of harmful microbes, control the spread of germs and protect the material itself from microbial corrosion, the antibacterial properties of composite materials has also been concerned by lots of researchers.

Now it is widely used to solve this problem by adding antibacterial additives to increase the resistance of the mold and bacteria[7-10]. However, the effect of antibacterial agents and their distribution on the mechanic properties of composites have been rarely explored so far[11-13]. Moreover, this study on the composite material used in the space station and other interior systems is extremely meaningful for the interior system of future space station[14] , which will set up a solid foundation.

In this paper, T700 / epoxy resin composites were prepared by hot-melt process and then experiments on their mechanic properties, combustion products, flame-retardant properties and antibacterial and mildew resistance were systematically carried out to find the relationship between concentrations of additives and properties.

2 MATERIALS AND METHODS

Carbon Fiber(T700-12K) was purchased from Toray(Tokyo, Japan). Epoxy resin(Grade: 602) was synthesized by Aerospace Research Institute of Materials and Processing Technology(Beijing, China) while antibacterial additions were bought from Beijing ChamGo Nano-Tech Co.,Ltd(Beijing, China). T700/602 prepregs with different additives' concentrations were prepared by hot melt method.Then all the samples were formed on flat steel mold. The information of mechanic and other tests' samples were shown as below.

Mechanic Samples: The thickness of samples were 2.00 mm. The ply stacking sequence, percentages of additives and testing standards were all listed in Table 1.

Samples for other tests: The thickness of samples were 0.50 mm. Other information were also included in Table 1. In the flame retardant experiment, horizontal and vertical burning test were both carried out.

Mechanical Samples	The percentage of additives/%	The ply stacking sequence	Testing standards
1	0%		GB/T 1447-2005
2	1%	$[0^o/90^o/\pm45^o]_{4s}$	QJ 1403A-2004,
3	2%		GB/T 3356-1999,
Flame retardant test	–	$[0^o/90^o/\pm45^o]_s$	HB7066-1994
Antibacterial test	–	$[0^o/90^o/\pm45^o]_s$	QB/T 2591-2003, GJB150.10A-2009

Table 1: The samples' information

3. RESULTS AND DISSCUSSIONS

3.1 Mechanic test results for T700/602 samples

All the results were listed in Table 2. Based on the experimental data, we can find that all the mechanic properties nearly became weaker along with the concentration of additives increasing. Therefore, the introduction of antibacterial additives will weaken the binding force between fibers and resins by some means.

	0%	1.00%	2.00%
Longitudinal tensile strength /MPa	793	750	679
Longitudinal tensile modulus/GPa	49.5	44.0	40.8
Transverse tensile strength /MPa	798	754	727
Transverse tensile modulus /GPa	51.1	44.9	40.9
Longitudinal compressive strength/MPa	635	523	533
Longitudinal compressive modulus /GPa	63.3	47.4	48.2
Transverse compressive strength/MPa	644	492	470
Transverse compressive modulus /GPa	69.4	46.8	47.1
Longitudinal bending strength /MPa	906	887	781
Longitudinal bending modulus /GPa	44.5	42.2	39.0
Transverse bending strength /MPa	901	797	752
Transverse bending modulus /GPa	42.8	39.4	37.5
ILSS /MPa	59.0	54.1	47.1

Table 2: Results for mechanic tests

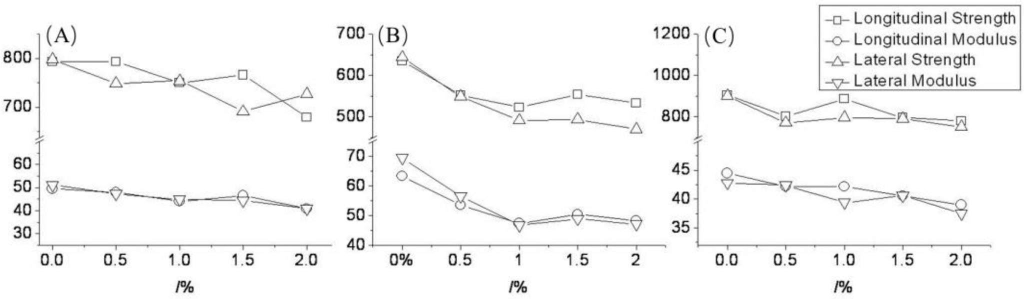

Figure 1 Results for mechanic tests: (A) Tensile test; (B) Compressive test; (C) Bending test.

To confirm this inference, mechanic properties with another two concentration of additives were also investigated. Experimental results were shown in Figure 1. We can easily get the information that Figure 1 shows a gradually decreasing trend. It means that adding different amounts of antimicrobial agents will correspondingly weaken their mechanic properties.

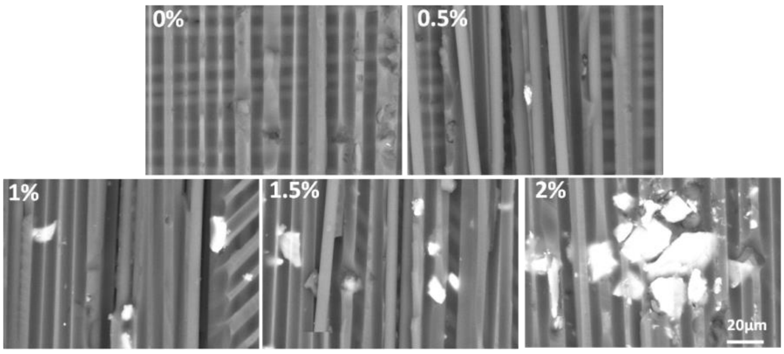

Figure 2 SEM results for samples with different concentration of antibacterial agent

Then SEM experiment was conducted to investigate the interface between fibers and resins so as to expose the distribution for the additives. Results were shown in Figure 2. Since antibacterial agents contains lots of silver ions, they will be brighter than other components. In this way, we can find that additives were distributed on the interface between fibers and resins, which will affect their interaction between them, especially ILSS.

3.2 Flame retardment test results

Flame retardment test were carried out to investigate their anti-flame properties. Based on the results listed in Table 3 and Table 4, we can easily find that all the production of combustion were far below the standard value. Samples without any antibacterial additives showed great potential application in flame-resistant material. However, since there are some organic components included in the agents and they will contributed to the test results, samples with 1% and 2% additives will get a higher concentration than samples without additives, especially for CO.

	CO	HF	HCl	NOx	SO_2	HCN
0%	277±15	-	3.0±1.7	9.0±1.7	0.3±0.6	2.3±0.6
1%	403±15	-	4.3±2.5	12±1	0.7±0.6	3.7±0.6
2%	420±30	-	6±3	12.3±2.1	0.3±0.6	3.7±1.5
Standard	≦3500	≦100	≦150	≦100	≦100	≦150

Table 3: Results for production of combustion

Moreover, in order to study on their flame-resistant properties, horizontal and vertical burning experiments were introduced. By comparing the results, all these samples had the outstanding flame retardment property without any flame penetration and drippage of melt, since their self-extinguishment time were all 0s.

		Burning time/s	Flame spread distance	Average flame spread rate	Test phenomenon
Horizontal burning	0%	0	0	0	No melt drippage
	1%	0	0	0	No melt drippage
	2%	0	0	0	No melt drippage
		Self-extinguishment time /s	Average burnt length /mm	Average duration of dripping /s	
Vertical burning	0%	0	80	-	
	1%	0	70	-	
	2%	0	87	-	

Table 4: Results for flame retardment test

Therefore, T700/602 samples without additives had a prominent flame-resistant property due to that their thickness were extremely thin. The introduction of additives did not affect it.

3.3 Antimicrobial test results

To control the breeding of harmful microbes, control the spread of germs and protect the material itself from microbial corrosion, antimicrobial test was necessarily carried out. The test standard were QB/T 2591-2003 and GJB150.10A-2009. The samples' thickness was 0.5 mm. Test duration was a month. Though samples with different concentrations of additives had the similar flame retardment properties or gradually weakened mechanic properties, they performed very different on antimicrobial test. Samples without additions did no harm to both *Staphylococcus aureus* and *Monilia albican*. When the concentration of antimicrobial additives was higher than 2%, it can meet the antimicrobial standard requirement, while samples with 1% antibacterial additives did well for *Staphylococcus aureus* and *E.Coli* but did not have the ability to kill *Monilia albican*.

	Antibacterial percentage/%			
	Staphylococcus aureus /%	*E.Coli.*/%	*Monilia albican* /%	Mildew proof level
0%	7.5	50	0	Level 0 *
1.0%	99	99	18	Level 0 *
2.0%	99	99	85	Level 0 *

* Level 0–No growth.No mold growth on materials.

To meet the antimicrobial standard requirement, we need choose 2% as the concentration of antimicrobial additives. Because if the concentration is higher than 2%, their mechanic property will be weakened to affect structural strength.

4. CONCLUSIONS

Through the introduction of additives, we finally got a novel series of composite faceplates with excellent flame retardment and antibacterial properties, achieving the integration of structure with functions. Though samples with different concentrations of additives had the similar flame retardment properties or gradually weakened mechanical properties, only the samples with more than 2%

additives can meet the antimicrobial standard requirement. This work can contribute a lot to the use on interior decoration system.

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