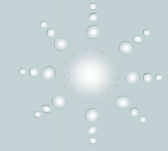




Leaching performance, decay and termite resistance of wood treated with borates incorporated with phenol-formaldehyde resin

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1. Introduction

Borates as Preservatives

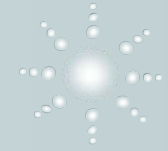
Advantages

- Effectiveness against insects and decay fungi
- Safe for the mammals and environment
- Colorless, odorless
- Ease of handling and treatment
- Flame retardance
- Low cost

Disadvantages

- Pure borates can not fix to the cell wall of wood
- Boron can be leached from treated wood as a result of their water solubility
- Can not adequately protect wood in ground contact and exterior applications

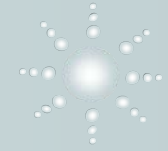
1. Introduction



❖ Methods of fixing boron in treated wood

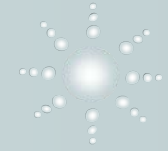
- Surface treatments
- Combination with water repellents, monomer and polymer
- Inorganic metal and borate combination
- Vapor boron treatment
- Combination with some natural substance such as proteins and tannins

1. Introduction



- ❖ **Wood impregnated with PF-resin**
 - For improving dimensional stability and mechanical strength.
 - Resistance to biodegradation.

2. *Materials and method*



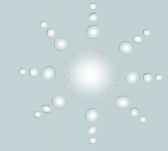
❖ 2.1 The objective of the Research

- To investigate the fixation of borates and the properties of the wood treated with the mixed solution of three borates and PF resin respectively.

❖ 2.2 Materials

- Sapwood of Chinese fir (*Cunninghamia lanceolata* Hook.) and Masson pine (*Pinus massoniana* Lamb.)
- Dimensions
19(R)×19(T)×19(L)mm for leaching test;
25(R)×25(T)×6(L)mm for termite test;
19(R)×19(T)×10(L)mm for decay resistance test;
20(R)×20(T)×20(L)mm for dimensional stability test.

2. Materials and method



❖ **2.3 Resin synthesis**

PF resin: Resol-type; low molecular weight

Molar ratio of phenol : formaldehyde = 1:2.0;

Catalyst: NaOH

❖ **2.4 Treatment of wood specimens**

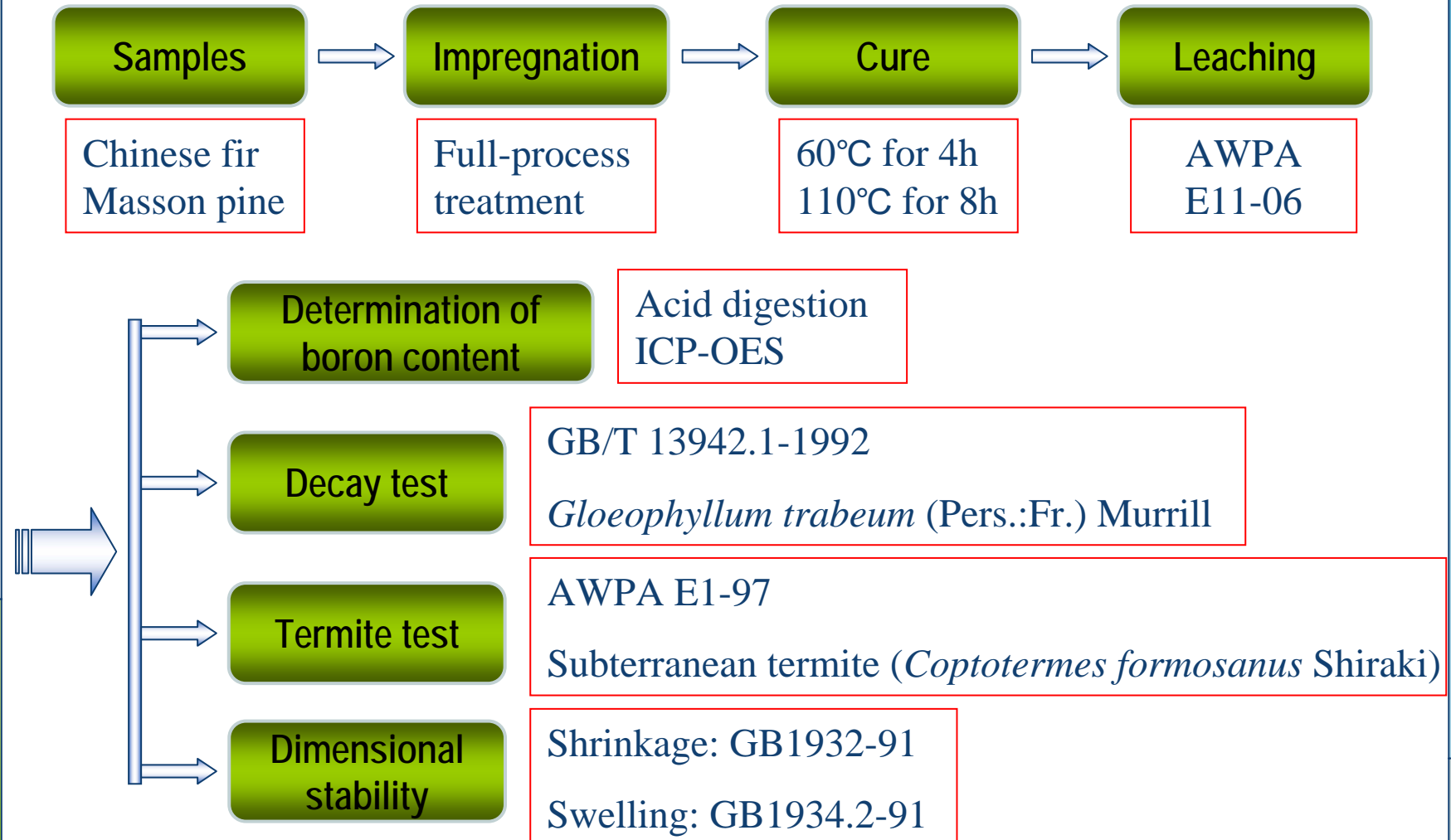
Borates: Boric acid (BA), borax (BX) and disodium octaborate tetrahydrate (DOT).

Concentration: 0.5%; 1.0%; 1.5%; 2.0%

PF resin: 20%

2. Materials and method

❖ Procedures



3. Results and Discussion

❖ 3.1 Leaching test

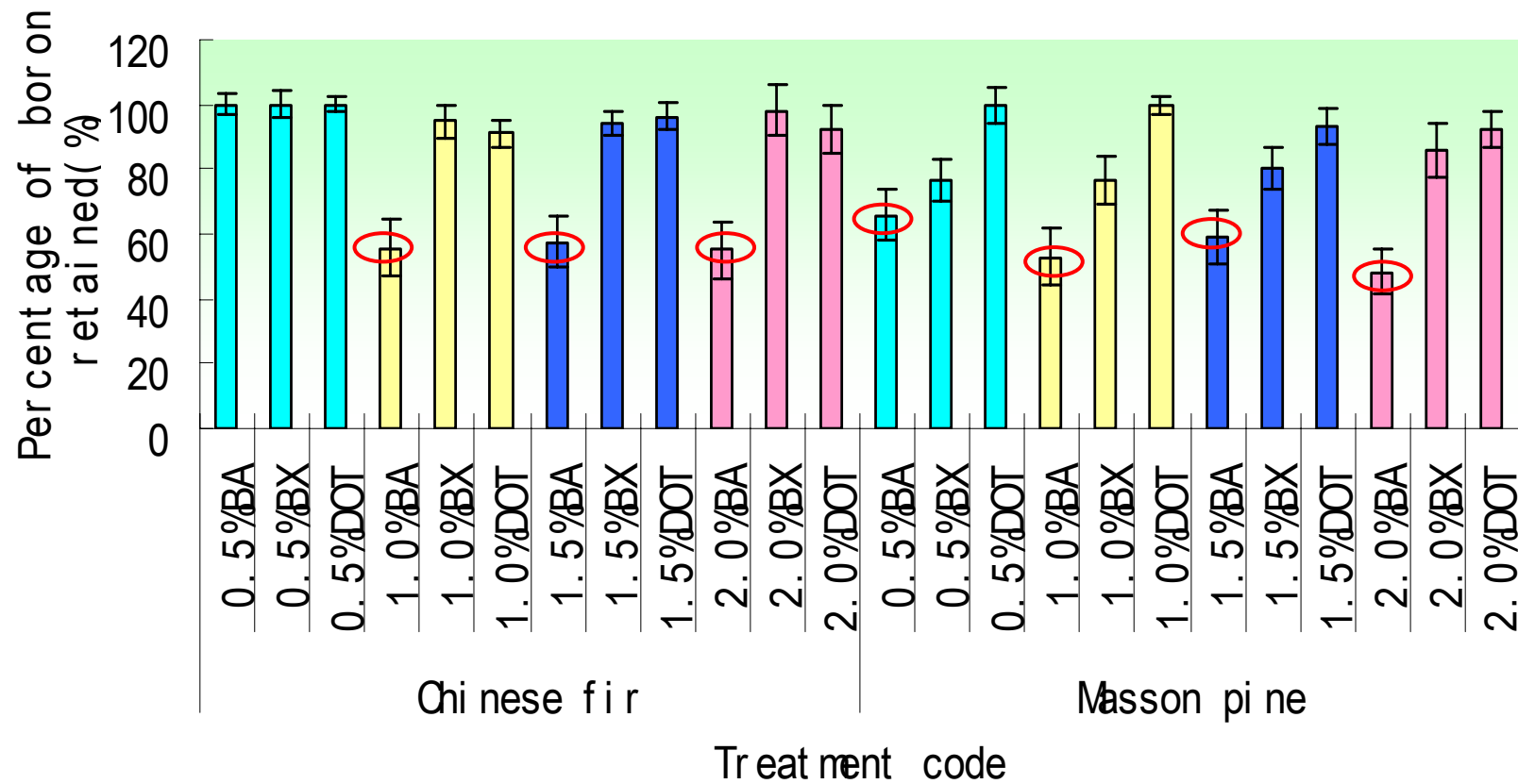
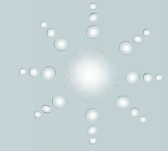


Fig.1 Percentage of boron retained of samples treated with PF resin-borates

3. Results and Discussion



❖ 3.2 Decay resistance test (Lab)

Tab.1 Mass loss of treated and untreated samples in the decay resistance test

Samples	Mass loss(%)	
	Chinese fir	Masson pine
Untreated	9.5	15
0.5% borates	≤ 1.5	≤ 2
1.0% borates	≤ 0.5	≤ 0.4
1.5% borates	≤ 0.6	≤ 0.7
2.0% borates	≈ 0	≈ 0

3. Results and Discussion

❖ 3.3 Termite resistance test (Lab)

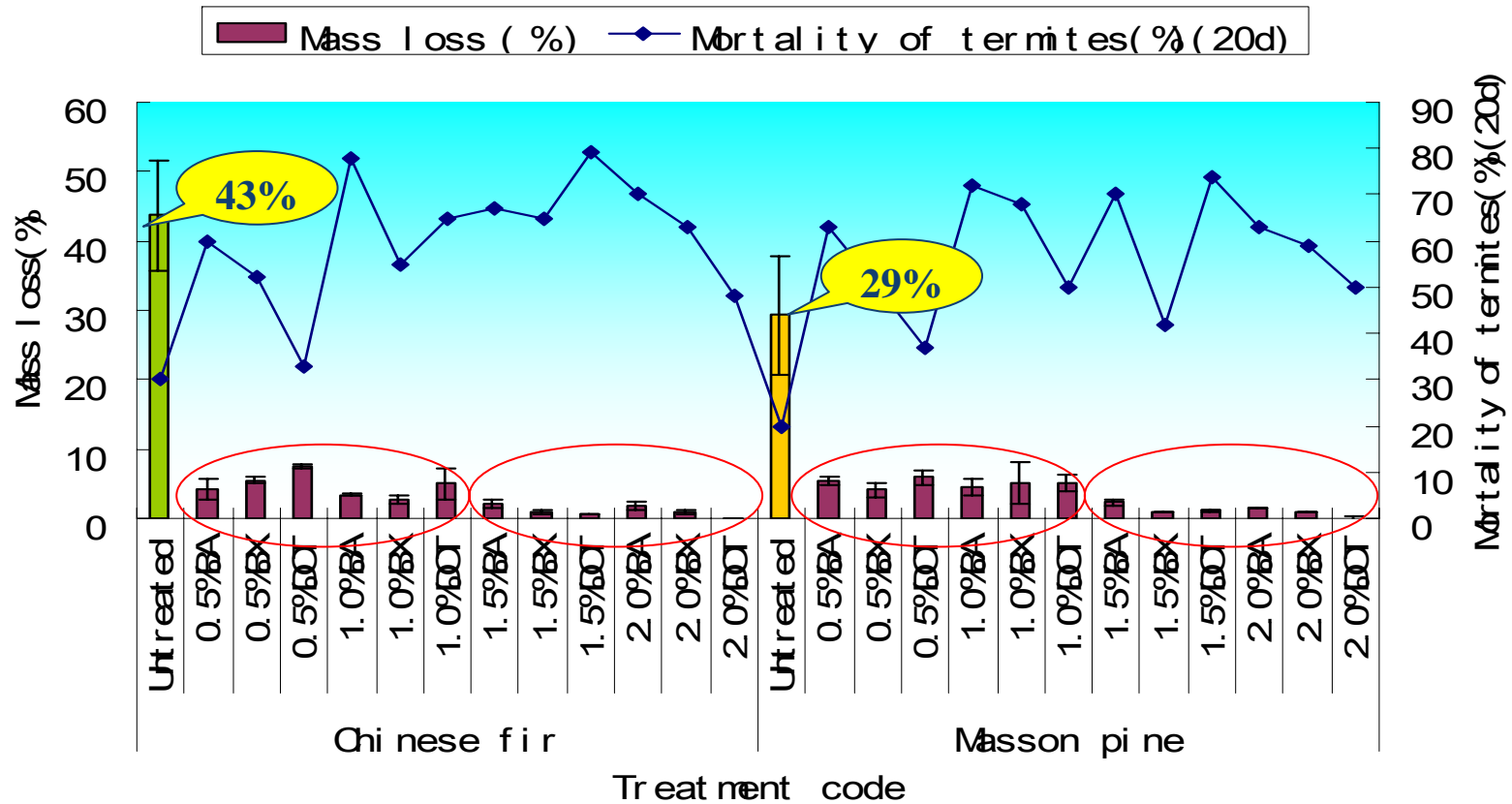


Fig.2 Mass loss of treated and untreated samples in termite test

3.3 Termite resistance tests

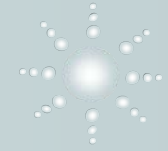


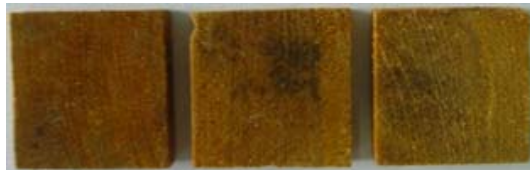
Fig.3 Photos of untreated Chinese fir samples attacked by termites



(a) 0.5%BX



(b) 1.0%BX



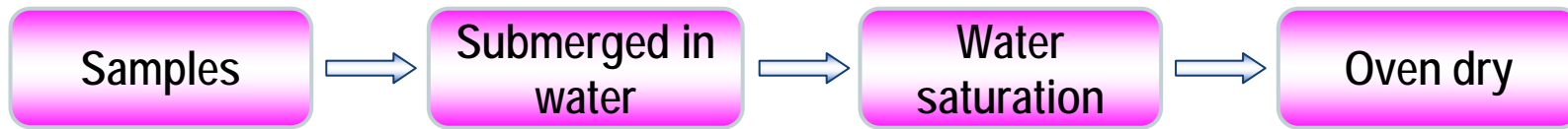
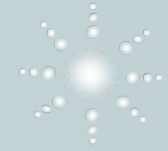
(c) 1.5%BX



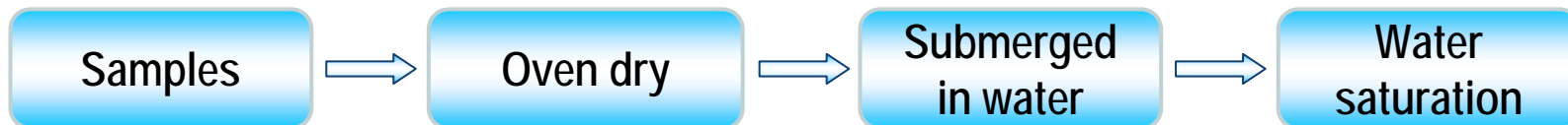
(d) 2.0%BX

Fig.4 Photos of Chinese fir samples treated with PF-BX after attack by termites

3.4 Dimensional stability



$$(1) \text{ Shrinkage rate} = \frac{\text{Dimension 1} - \text{Dimension 2}}{\text{Dimension 1}} \times 100\%$$



$$(2) \text{ Swelling rate} = \frac{\text{Dimension 1} - \text{Dimension 2}}{\text{Dimension 2}} \times 100\%$$

Dimension 1: the dimension of sample saturated with water

Dimension 2: the dimension of oven dry sample

Tab.2 Shrinkage rates of samples treated with PF-borates

Treatment	Shrinkage rate (%)					
	Chinese fir			Masson pine		
	Radial	Tangential	Volume	Radial	Tangential	Volume
Untreated	4.67	8.28	13.92	5.24	8.22	14.03
0.5%BA	2.72	5.19	8.06	3.59	5.31	8.98
0.5%BX	2.42	4.30	6.47	3.14	4.55	7.18
0.5%DOT	2.06	4.22	6.51	2.55	4.47	7.32
1.0%BA	2.43	6.01	8.06	2.15	4.42	7.15
1.0%BX	2.52	4.77	7.24	2.37	4.51	7.48
1.0%DOT	2.26	5.88	8.23	2.93	5.28	8.06
1.5%BA	2.29	4.97	7.75	3.58	5.76	8.95
1.5%BX	2.74	5.66	8.45	2.56	4.61	7.61
1.5%DOT	2.83	5.10	7.99	2.84	4.16	7.11
2.0%BA	2.81	5.41	8.49	3.28	5.37	8.38
2.0%BX	2.62	5.26	7.79	3.06	5.18	8.70
2.0%DOT	1.34	3.62	6.07	2.44	5.27	7.11

Tab.3 Swelling rates of samples treated with PF-borates

Treatment	Swelling rate (%)					
	Chinese fir			Masson pine		
	Radial	Tangential	Volume	Radial	Tangential	Volume
Untreated	4.89	9.03	17.17	5.54	8.97	16.36
0.5%BA	2.79	5.48	8.78	3.72	5.61	9.86
0.5%BX	2.48	4.49	6.92	3.24	4.76	7.73
0.5%DOT	2.11	4.41	6.97	2.63	4.68	7.91
1.0%BA	2.49	6.40	8.78	3.55	4.98	9.24
1.0%BX	2.59	5.02	7.82	2.43	4.72	8.09
1.0%DOT	2.32	6.25	9.00	3.02	5.57	8.77
1.5%BA	2.34	5.23	8.19	3.22	5.22	8.79
1.5%BX	2.82	6.00	9.24	2.72	4.28	8.05
1.5%DOT	2.92	5.37	8.69	2.44	4.50	8.26
2.0%BA	1.96	4.09	6.08	3.00	5.40	9.06
2.0%BX	2.81	5.24	8.09	2.18	4.29	8.54
2.0%DOT	2.89	5.71	9.28	2.85	4.72	7.31

4. Conclusion

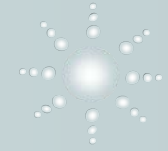
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A good fixation of borates in treated wood could be provided by PF resin. Among the three borates, the incorporation of PF-DOT and PF-BX showed the better effect. Because of the weak acidity of BA, the results were a little worse than the other two types of borates.

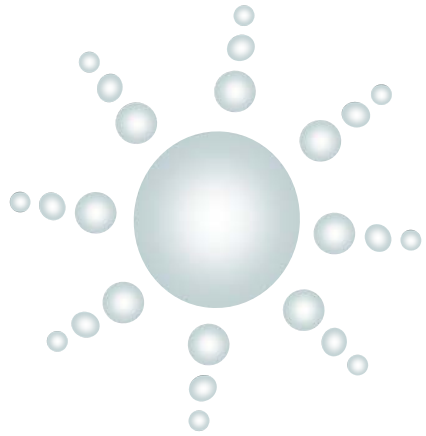
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The incorporation of PF-resin and three borates (BA, BX, DOT) provided excellent biological resistance against both termite and fungi. And with the increase of the concentration of borates the mass loss decreased. The dimensional stability of treated wood were also improved. The field tests would be carried out in the future.

5. Acknowledgement



- ❖ Senior Engineer Xuexiang He of Guangdong Forest Research Institute.



Thank You !