Development of boron/linseed oil combined treatment as wood protection

Evaluation of boron fixation and resistance to termites according to Japanese and European standards

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Background and objectives

Boron compounds: Boric acid (H_3BO_3), Anhydrous Borax ($Na_2B_4O_7$), Disodium octaborate tetrahydrate ($Na_2B_8O_{13}.4H_2O$)

- Efficient to prevent and cure degradations of wood by fungi and insects
- Environmentally acceptable
- **Highly leachable**

Water repellents/oil treatments:

- Low impact on environment
- Water transfert retardant and physical barrier

---> Temporarely efficient against fungi

---> Unefficient against insects

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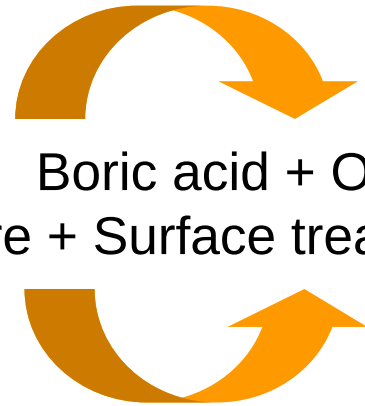


JIS standard : Treatment & Leaching

Dimensions
10 X 20 X 20 mm (L, R, T)

Japanese Cedar
Cryptomeria japonica

Japanese Beech
Fagus crenata

Boric acid solutions
0.25, 0.5, 1 , 2 % $^{w}/_{w}$

Coating of end-grain with epoxy glue

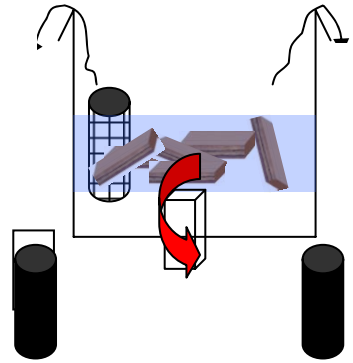
Oil heat treatment

Linseed oil

Soybean oil

Rapeseed oil

130°C/1h – 80°C/1h
Air drying



Weathering procedure
1 vol. wood/10 vol water

Japanese standard method K 1571 (JIS 2004)

10 cycles :
8 hrs immersion – 27°C
Stirring
+
16 hrs drying – 60°C

JIS standard : Treatment & Leaching

Dimensions
10 X 20 X 20 mm (L, R, T)

Japanese cedar
Cryptomeria japonica

Japanese beech
Fagus crenata

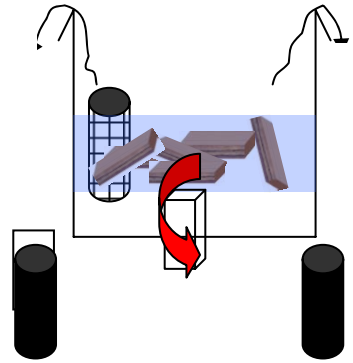
Sapwood

Boric acid solutions
0.25, 0.5, 1 , 2 % $^{w}/_{w}$

Coating of end-grain with epoxy glue

Oil heat treatment

Air drying



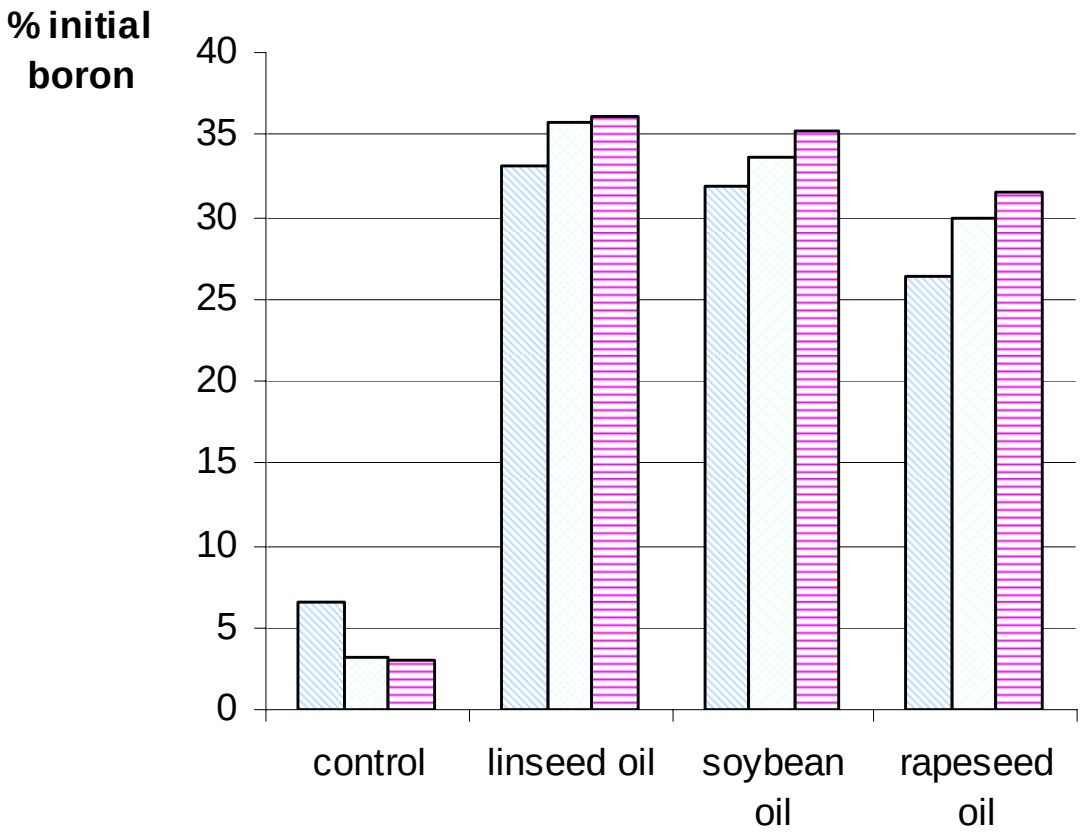
Weathering procedure
1 vol. wood/10 vol water

Analysis of **boron retention** after weathering (ICP)

Resistance to subterranean termites
Coptotermes formosanus

Japanese standard method K 1571 (JIS 2004)

Boron retention

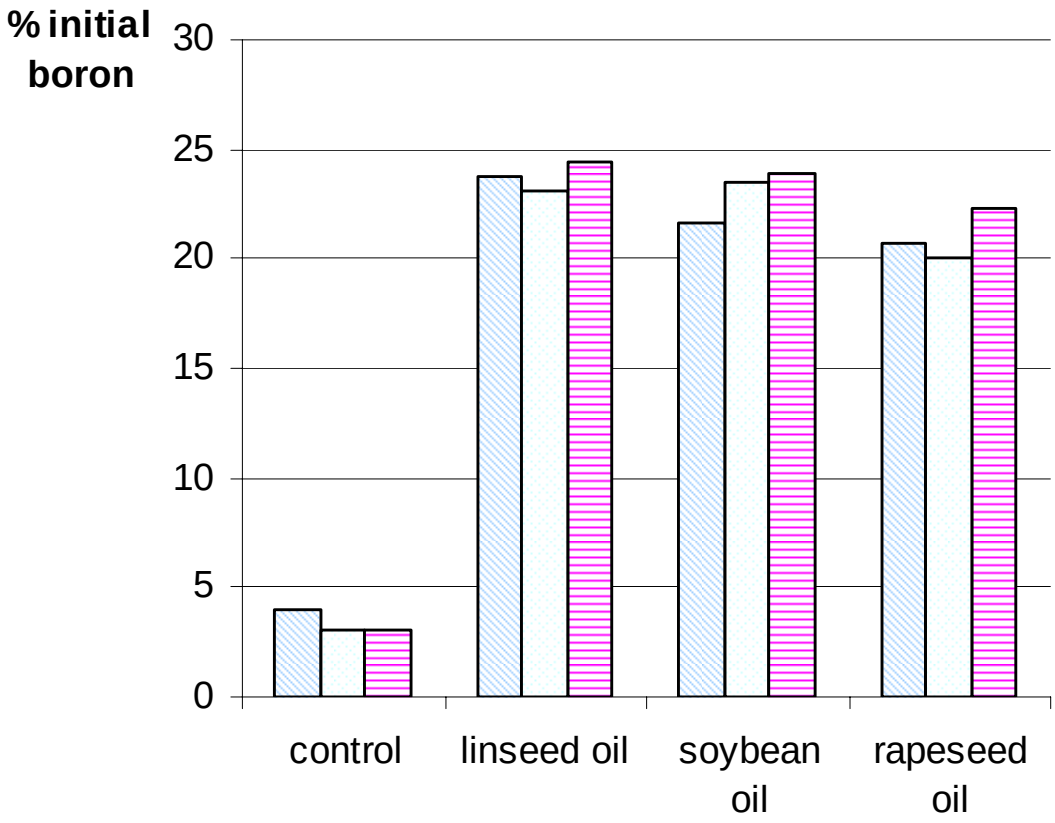


Cedar

Boron retention of linseed oil, soybean oil or rapeseed oil treated sapwood specimens

Boric acid. 0.25 % , 0.5% , 1.0 % $^{w}/_{w}$

Boron retention



Beech

Boron retention of linseed oil, soybean oil or rapeseed oil treated sapwood specimens

Boric acid. 0.25 % , 0.5% , 1.0 % $^{w}/_{w}$

EN standard : Treatment & Leaching

Dimensions
50 X 25 X 15 mm (L, R, T)

Pine
Pinus sylvestris

Sapwood

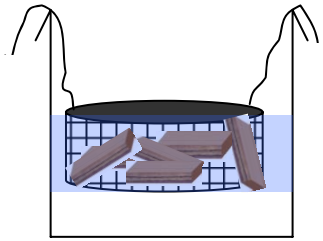
Boric acid solutions
0.25, 0.5, 1 , 2 % $^{w}/_{w}$

Coating of end-grain with epoxy glue

Oil heat treatment

Linseed oil

130°C/1h – 80°C/1h.
Air drying



Weathering procedure.
1 vol. wood/5 vol water

European standard method EN 84 (1997)

Cycles :
Wood immersed
15 min – Vacuum
+
14 days immersion
9 water changes

Treatment & Leaching

Dimensions
50 X 25 X 15 mm (L, R, T)

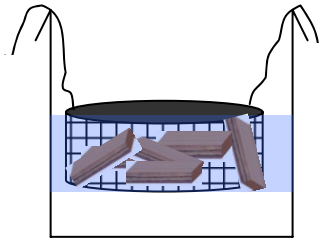
Pine
Pinus sylvestris

Sapwood

Boric acid solutions
0.25, 0.5, 1 , 2 % $^{w}/_{w}$

Coating of extremities with epoxy glue

Oil heat treatment



Weathering procedure. 1 vol. wood/5 vol water

European standard method EN 84 (1997)

Resistance to subterranean termites
Reticulitermes santonensis

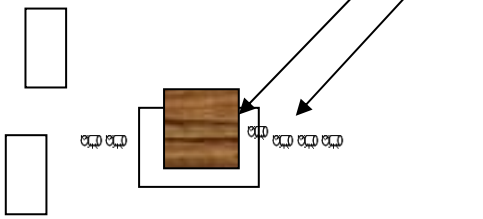
European standard method EN117 (2005)

Termite resistance test – K1571 – JIS 2004

T= 28°C

RH= 85 %

Obscurity



Acrylic cylinder with plaster bottom

1 specimen 10 X 20 X 0 mm (L,R,T)

+ 165 termites (150 workers/ 15 soldiers)

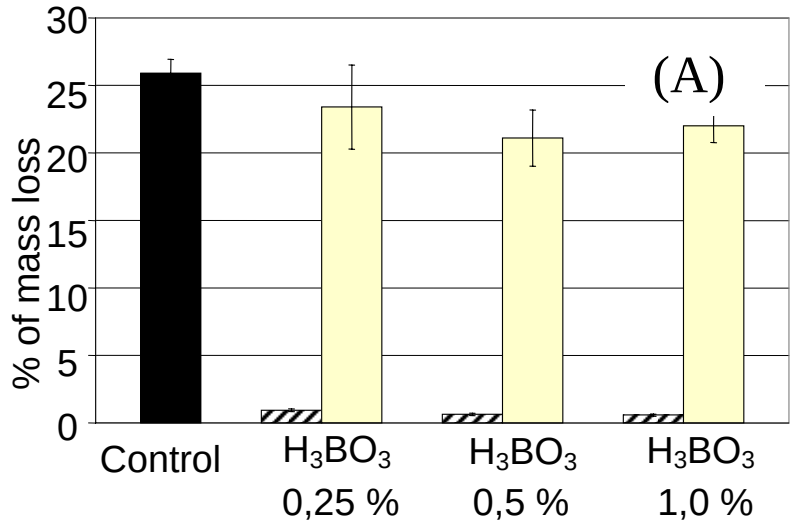
Coptotermes formosanus

Time: 3 weeks

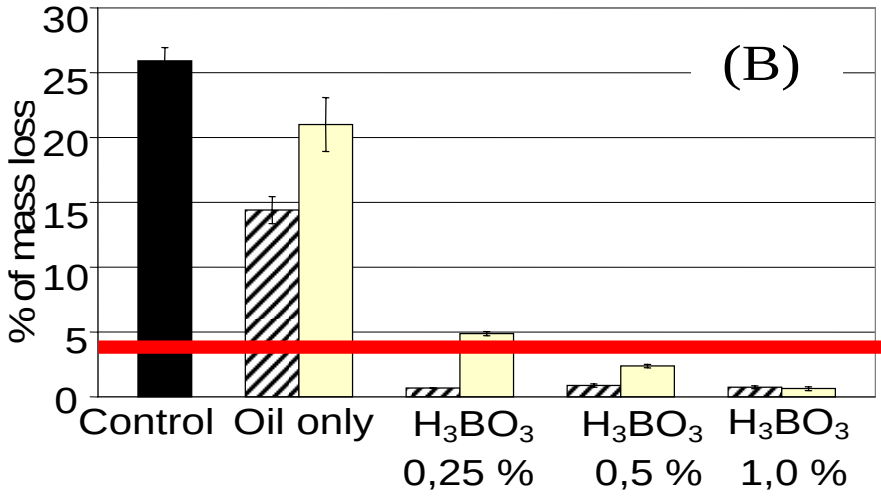
Termite impact is evaluated as the **mass loss** of sample after exposure

5 replicates / treatment

JIS Termite resistance test – Cedar



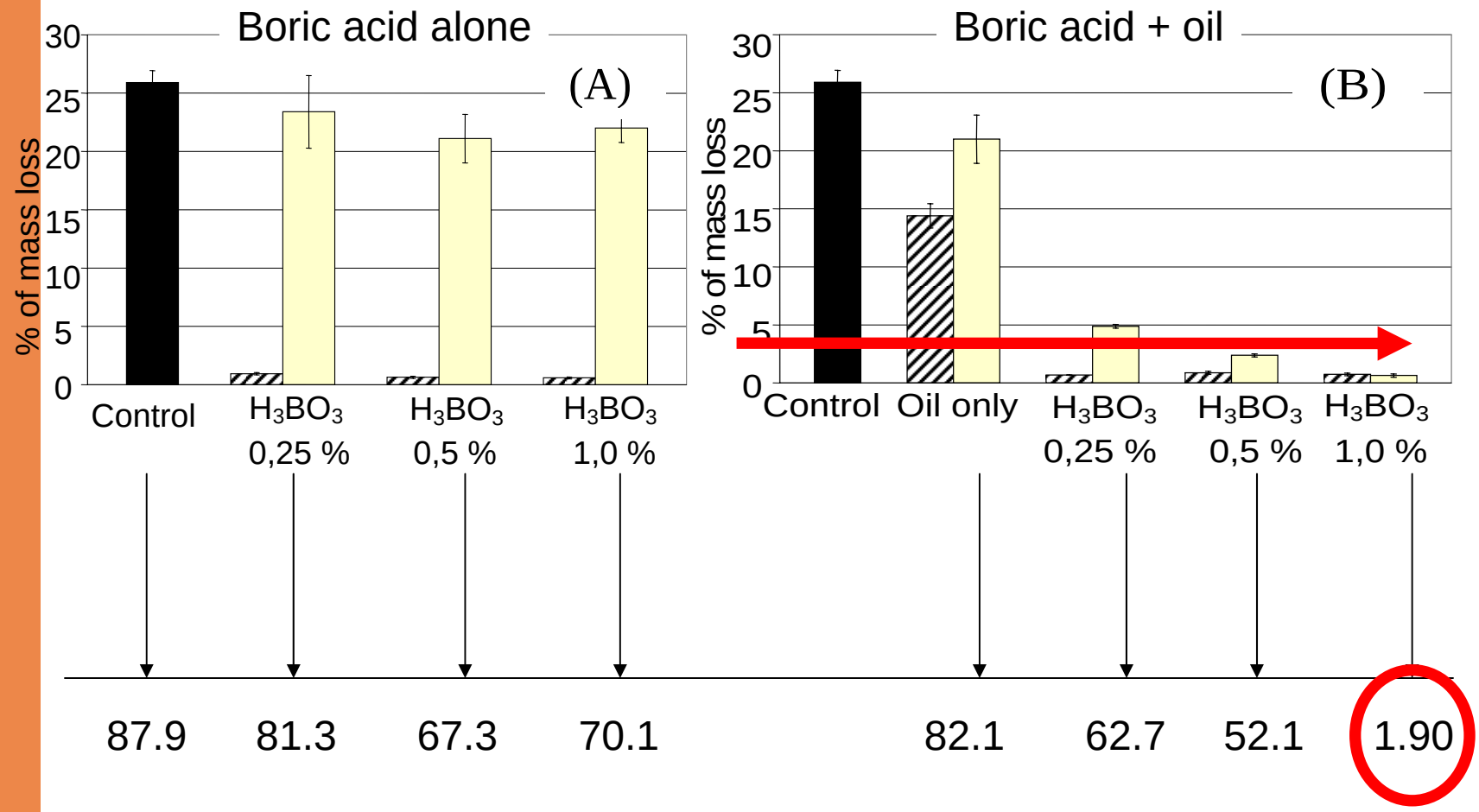
Boric acid alone



Boric acid + linseed oil

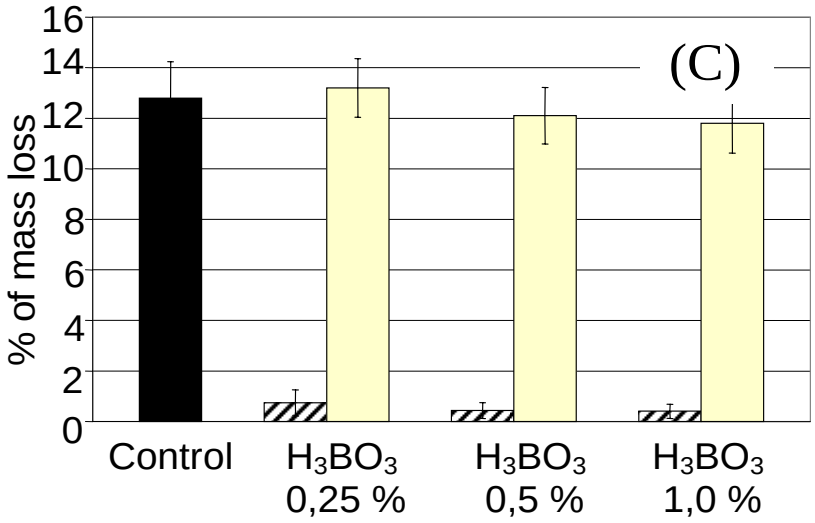
3 % mass loss

JIS Termite resistance test – Cedar

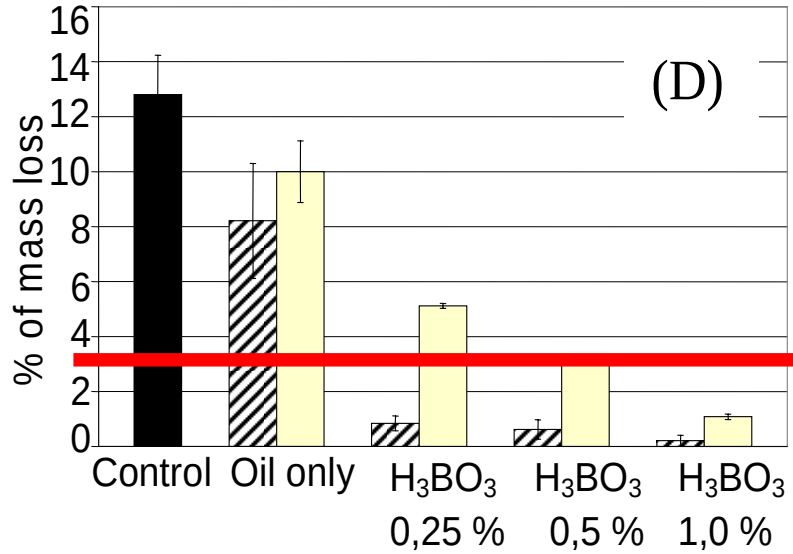


Termites' survival rate for **leached samples** (%)

JIS Termite resistance test – Beech



Boric acid alone



Boric acid + linseed oil

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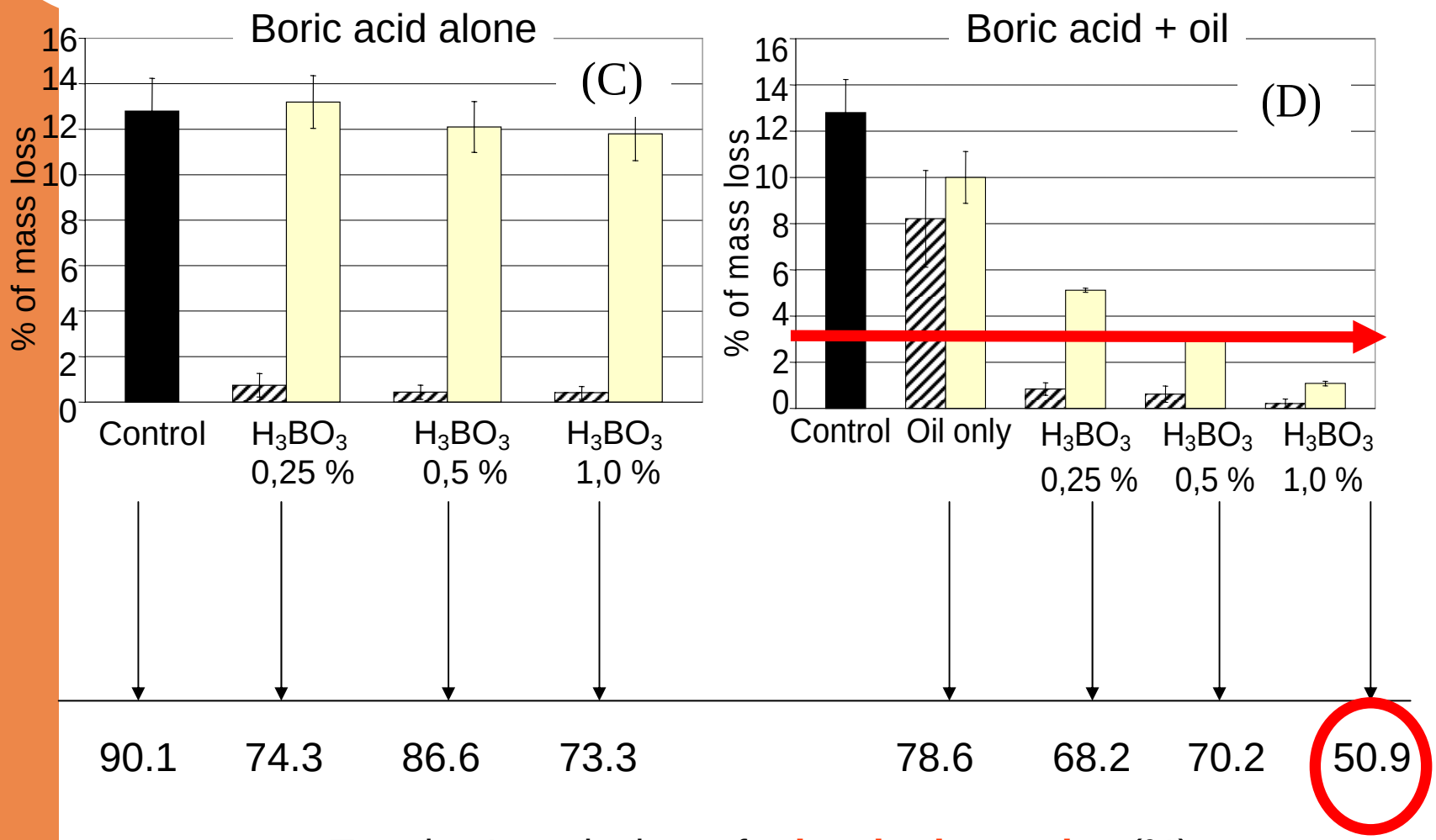
Termite resistance test – Beech



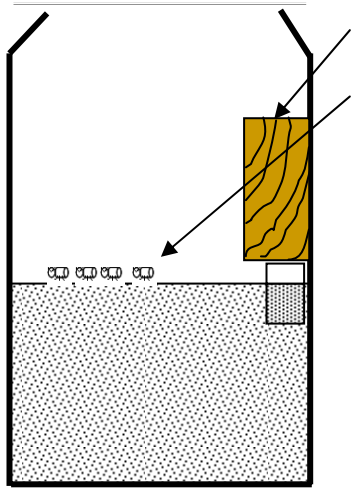
Termites' survival rate for **leached samples** (%)

EN Termite resistance test – EN 117

T= 27°C

RH= 75 %

Obscurity



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1 specimen 50 X 25 X 15 mm (L,R,T) – Pine sapwood

+ 260 termites (250 workers / 5 soldiers / 5 nymphs)

Reticulitermes santonensis

Time: 8 weeks.

Termite impact is evaluated by

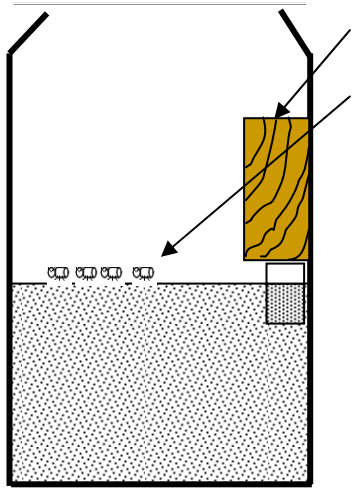
visual examination of sample after exposure

EN Termite resistance test – EN 117

T= 27°C

RH= 75 %

Obscurity



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1 specimen 50 X 25 X 15 mm (L,R,T) – Pine sapwood

+ 260 termites (250 workers / 5 soldiers / 5 nymphs)

Reticulitermes santonensis

Time: 8 weeks.

Termite impact is evaluated by **visual examination** of sample after exposure

5 replicates / treatment

0 = no attack
1 = attempted attack
2 = slight attack
3 = average attack
4 = strong attack

Quotation « 0 or 1 »

Quotation « 2 » for 1 sample max

Efficient product

EN 117 - Results

Treatment	Attack level (% Frequency)	Survival (%)
Linseed oil Unleached	4 (100%)	45
Leached	4 (100%)	48.1
H_3BO_3 2% Unleached	1(80%) – 2(20%)	0
H_3BO_3 2% Leached	4 (100%)	38.4
Control	4 (100%)	67.4

EN 117 - Results

Treatment	Attack level (% Frequency)	Survival (%)
H_3BO_3 0.5% + Oil		
Unleached	2(40%) – 3(60%)	0
Leached	3(100%)	32.2
H_3BO_3 1% + Oil		
Unleached	2(60%) – 3(40%)	0
Leached	3(100%)	15.1
H_3BO_3 2% + Oil		
Unleached	0(20%) – 1(80%)	0
Leached	2(20%) – 3(80%)	0

Conclusions

- Addition of linseed oil to boric acid treated wood improves boron retention after leaching
- A combined linseed oil/boric acid treatment improves the termite resistance of leached treated wood

Japanese standard JIS K1571:
(Boric acid 1% + linseed oil) treatment + leaching
= efficient treatment

European standards EN117 + EN84:
(Boric acid 2% + linseed oil) treatment + leaching
= Not efficient enough

Results / Termite test

Cryptomeria Japonica D.Don	Retention load of unleached samples (Kg/m^3 BAE) (1)	Boron retained after leaching (Kg/m^3 BAE) (2)	Mass loss by termites (%), mean (SD) (3)		Termite mortality (%), mean (SD) (3)	
Treatment	Kg/m3 BAE		Leached	Unleached	Leached	Unleached
L	-	-	21.0 (2.08)	14.4 (1.04)	27.9 (3.15)	45.5 (4.71)
S	-	-	24.4 (2.14)	10.7 (1.09)	35.7 (2.98)	30.3 (3.24)
R	-	-	12.8 (1.11)	7.62 (0.69)	51.8 (5.42)	60.0 (4.36)
0.25% control	2.15 (0.28)	0.14 (0.17)	23.4 (3.12)	0.94 (0.10)	28.7 (4.24)	75.4 (3.01)
0.25 % / L	2.02 (0.14)	0.67 (0.22)	4.88 (0.16)	0.68 (0.02)	37.3 (2.20)	74.6 (4.21)
0.25 % / S	1.91 (0.13)	0.61 (0.14)	4.59 (0.10)	0.48 (0.15)	40.7 (7.41)	69.9 (3.80)
0.25 % / R	2.09 (0.20)	0.55 (0.09)	5.07 (0.21)	0.33 (0.17)	53.6 (7.61)	84.0 (6.11)
0.50 % control	4.25 (0.11)	0.13 (0.11)	21.1 (2.08)	0.64 (0.09)	32.7 (5.41)	100 (0.00)
0.50 % / L	4.13 (0.17)	1.48 (0.10)	2.38 (0.13)	0.88 (0.12)	47.9 (1.20)	100 (0.00)
0.50 % / S	4.39 (0.15)	1.44 (0.08)	2.54 (0.14)	0.61 (0.05)	53.7 (8.64)	100 (0.00)
0.50 % / R	4.23 (0.09)	1.27 (0.10)	2.91 (0.29)	0.43 (0.07)	61.6 (6.82)	100 (0.00)
1.00 % control	8.03 (0.09)	0.21 (0.04)	22.0 (1.24)	0.58 (0.08)	29.9 (4.11)	100 (0.00)
1.00 % / L	8.36 (0.18)	3.02 (0.11)	0.64 (0.15)	0.74 (0.11)	98.1 (0.33)	100 (0.00)
1.00 % / S	7.94 (0.21)	2.80 (0.12)	0.54 (0.14)	0.41 (0.08)	94.5 (3.27)	100 (0.00)
1.00 % / R	8.07 (0.16)	2.82 (0.07)	0.91 (0.11)	0.33 (0.06)	92.4 (1.95)	100 (0.00)
Untreated control			25.9 (1.04)		12.1 (3.28)	

Results / Termite test

Fagus Crenata Blume	Retention load of unleached samples (Kg/m^3 BAE) (1)	Boron retained after leaching (Kg/m^3 BAE) (2)	Mass loss by termites (%), mean (SD) (3)		Termite mortality (%), mean (SD) (3)	
Treatment	Kg/m3 BAE		Leached	Unleached	Leached	Unleached
L	-	-	10.0 (1.12)	8.21 (2.09)	21.4 (2.25)	39.0 (2.13)
S	-	-	11.3 (1.18)	7.65 (0.64)	28.3 (5.21)	32.2 (5.26)
R	-	-	10.4 (1.06)	5.76 (0.51)	42.3 (4.25)	44.2 (4.21)
0.25% control	1.74 (0.12)	0.07 (0.08)	13.2 (1.16)	0.74 (0.52)	25.7 (3.00)	40.2 (2.12)
0.25 % / L	1.68 (0.21)	0.40 (0.18)	5.12 (0.09)	0.84 (0.27)	31.8 (2.20)	48.2 (6.05)
0.2 5% / S	1.80 (0.09)	0.39 (0.07)	5.09 (0.29)	0.98 (0.30)	29.1 (2.34)	52.9 (4.74)
0.25 % / R	1.69 (0.14)	0.35 (0.11)	4.87 (0.24)	0.66 (0.11)	48.6 (6.74)	59.2 (3.46)
0.50 % control	3.55 (0.24)	0.11 (0.12)	12.1 (1.12)	0.44 (0.31)	23.4 (2.23)	100 (0.00)
0.50 % / L	3.55 (0.09)	0.82 (0.24)	3.17 (0.35)	0.62 (0.08)	29.8 (5.10)	100 (0.00)
0.50 % / S	3.37 (0.12)	0.79 (0.11)	3.54 (0.14)	0.31 (0.10)	32.3 (2.32)	100 (0.00)
0.50 % / R	3.58 (0.20)	0.72 (0.15)	3.84 (0.19)	0.65 (0.09)	47.4 (5.27)	100 (0.00)
1.00 % control	7.16 (0.07)	0.22 (0.11)	11.8 (1.18)	0.41 (0.28)	26.7 (2.21)	100 (0.00)
1.00 % / L	6.97 (0.13)	1.70 (0.09)	1.08 (0.20)	0.21 (0.10)	49.1 (3.29)	100 (0.00)
1.00 % / S	6.92 (0.09)	1.65 (0.15)	0.91 (0.13)	0.39 (0.05)	58.4 (5.08)	100 (0.00)
1.00 % / R	7.14 (0.14)	1.59 (0.10)	1.04 (0.12)	0.50 (0.09)	63.8 (2.40)	100 (0.00)
Untreated control			12.8 (1.44)		9.93 (4.42)	