

Evaluation of boric acid/vegetable oil combinations for wood biological resistance and boron fixation

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Background and objectives

Boron compounds: Boric acid (H_3BO_3), Anhydrous Borax ($\text{Na}_2\text{B}_4\text{O}_7$),
Disodium octaborate tetrahydrate ($\text{Na}_2\text{B}_8\text{O}_{13}\cdot 4\text{H}_2\text{O}$)

- Efficient to prevent and cure degradations of wood by fungi and insects.
- Low mammalian toxicity.

Highly leachable ---> Short service life of wooden commodities

Water repellents/oil treatments:

- Low impact on environment.
- Water transfert retardant and mechanical barrier

---> Temporarily efficient against fungi

---> **Unefficient against insects**

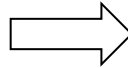
Material and methods



Dimensions:
50 X 25 X 15 mm (L X R X T).

Japanese cedar (*Cryptomeria japonica*)

Boric acid solutions
(0.5, 1.0, 2.0 et 5.0 % w/w).

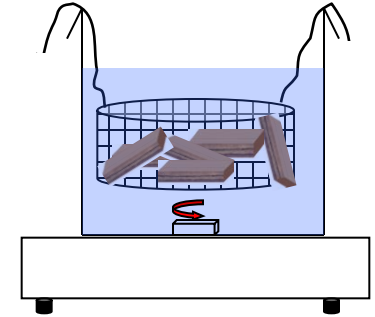
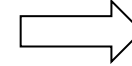


Coating of extremities
with epoxy glue

Oil heat treatment

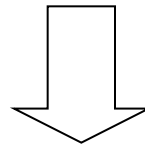
130°C/1h – 60°C/1h.

Air drying



Weathering procedure.
1 vol. wood/10 vol water

Japanese standard method
K 1571 (JIS 2004)

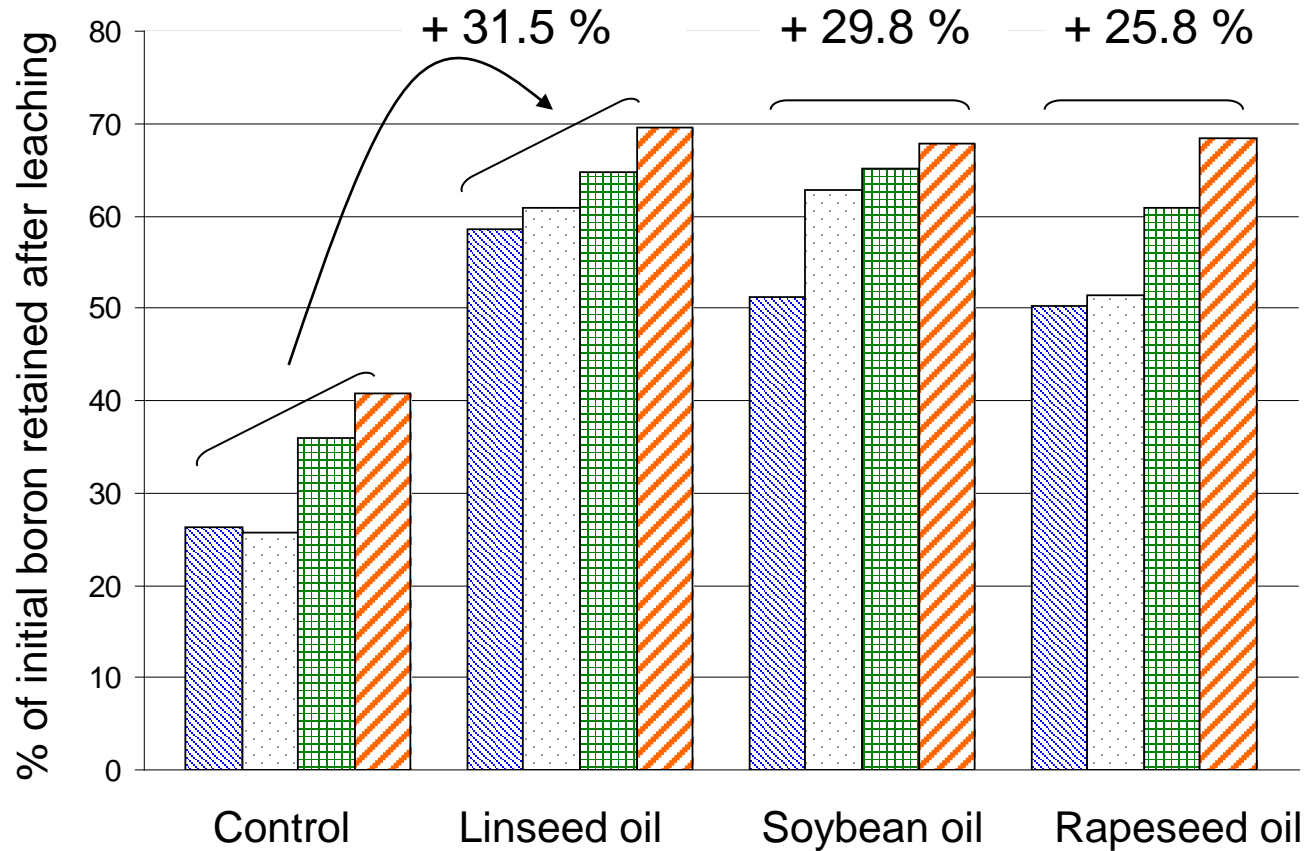


Analysis of **boron retention** after
weathering





**Resistance to
subterranean termites**
Coptotermes formosanus
Japanese standard method
K 1571 (JIS 2004)

Resistance to fungi
Trametes Versicolor
(White-rot) and
Fomitopsis Palustris
(Brown-rot). Japanese
standard method K 1571
(JIS 2004)

Results and discussion/ Boron retention



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

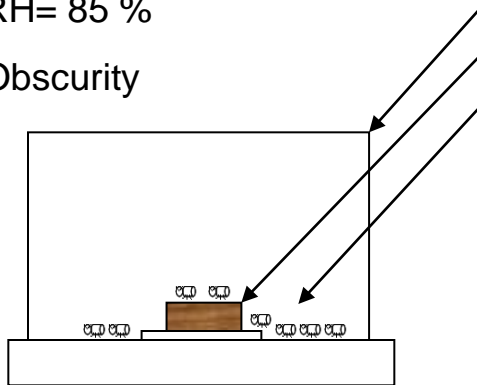
Boric acid. 0.5 %  , 1.0%  , 2.0 %  and 5.0 %  w/w

Material and methods / Termite resistance test

T= 28°C

RH= 85 %

Obscurity



Acrylic cylinder with plaster bottom.

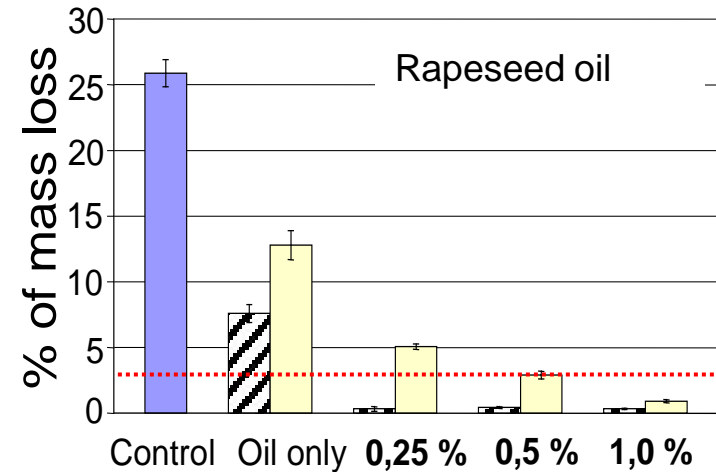
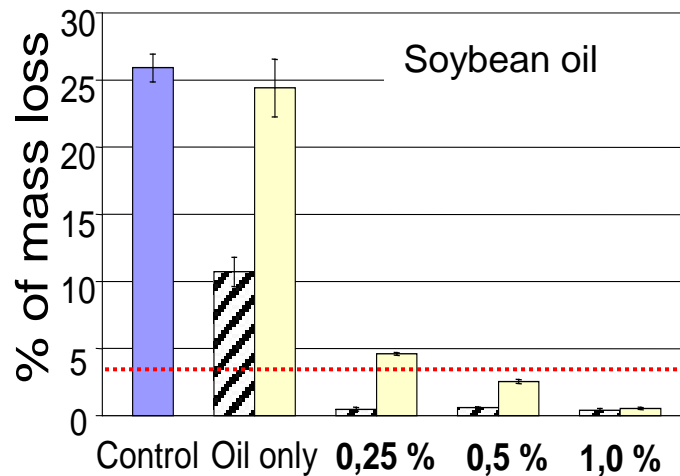
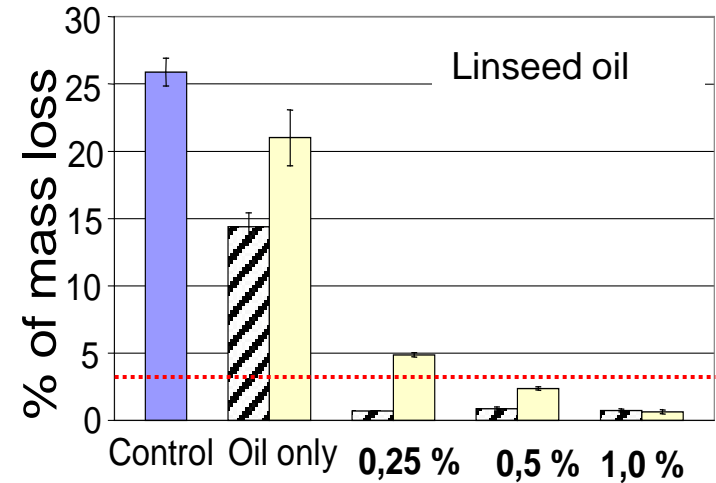
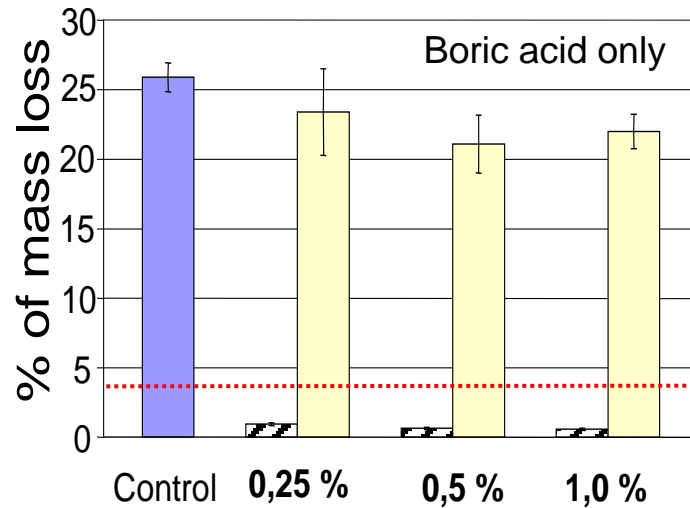
1 specimen 20 X 10 X 10 mm (L X R X T). *C. japonica*
+ 165 termites (150 workers/ 15 soldiers) *Coptotermes formosanus*.

Time: 3 weeks.

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

Japanese standard method K 1571 (JIS 2004)





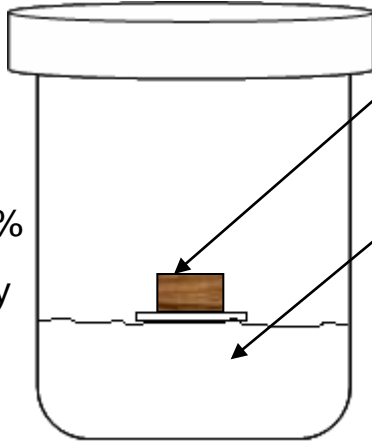
Mass losses of Japanese cedar sapwood specimens exposed to subterranean termite *Coptotermes formosanus*

Japanese standard method K 1571 (JIS 2004)

Control ■ Weathered ■ Unweathered 3% of mass loss ⋯

Material and methods / Decay test

T= 26°C
RH= 85 %
Obscurity



Sterilized glass jars containing:

- 3 specimens 40 X 20 X 5 mm (L X R X T). *C. japonica*
- 250 g of quartz salt
- 80/85 ml of glucose/ peptone/ malt extract in water
- *Trametes versicolor* or *Fomitopsis palustris*

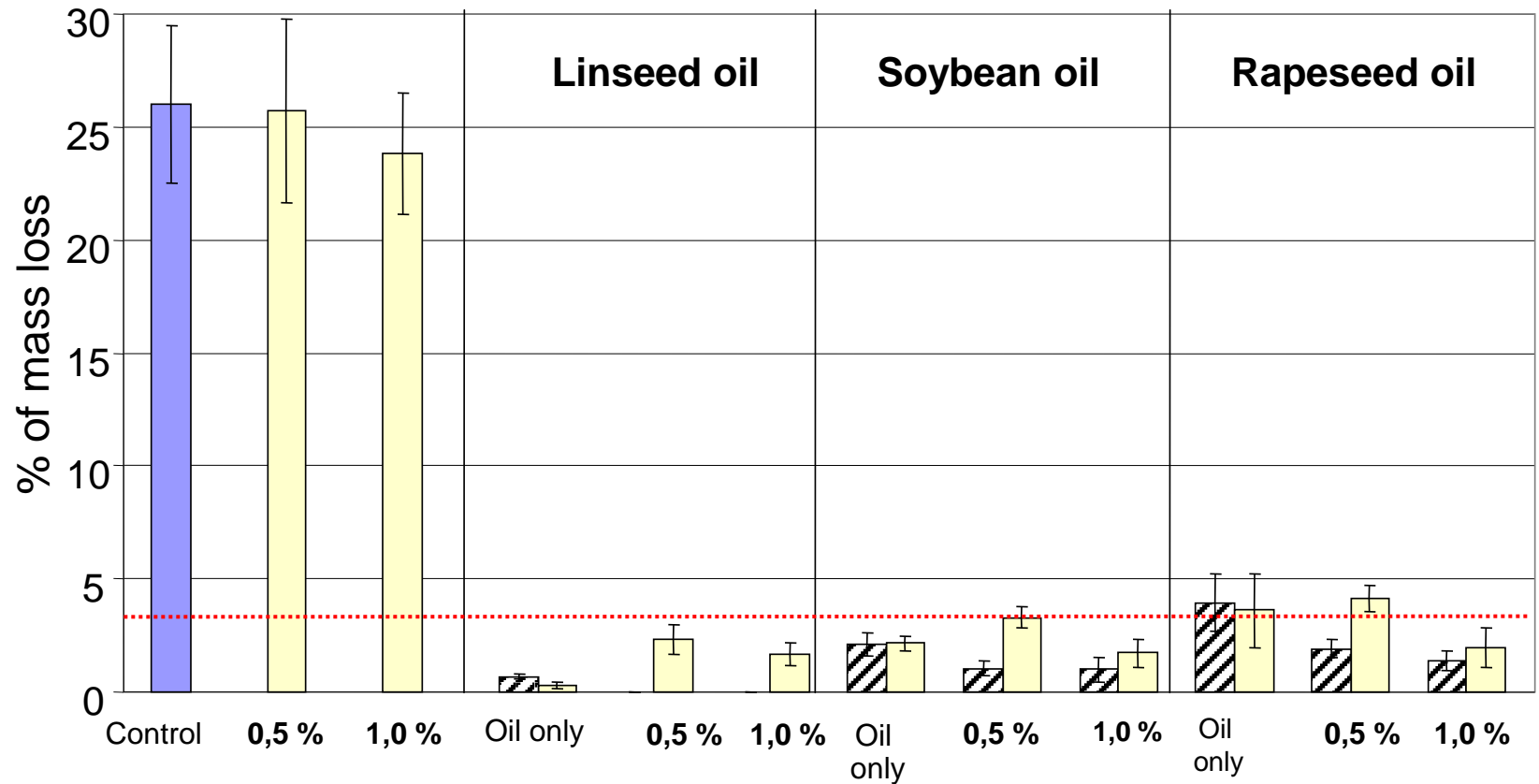
Exposure time: 12 weeks.

Fungi impact is evaluated as the mass loss of sample after exposure

Japanese standard method K 1571 (JIS 2004)



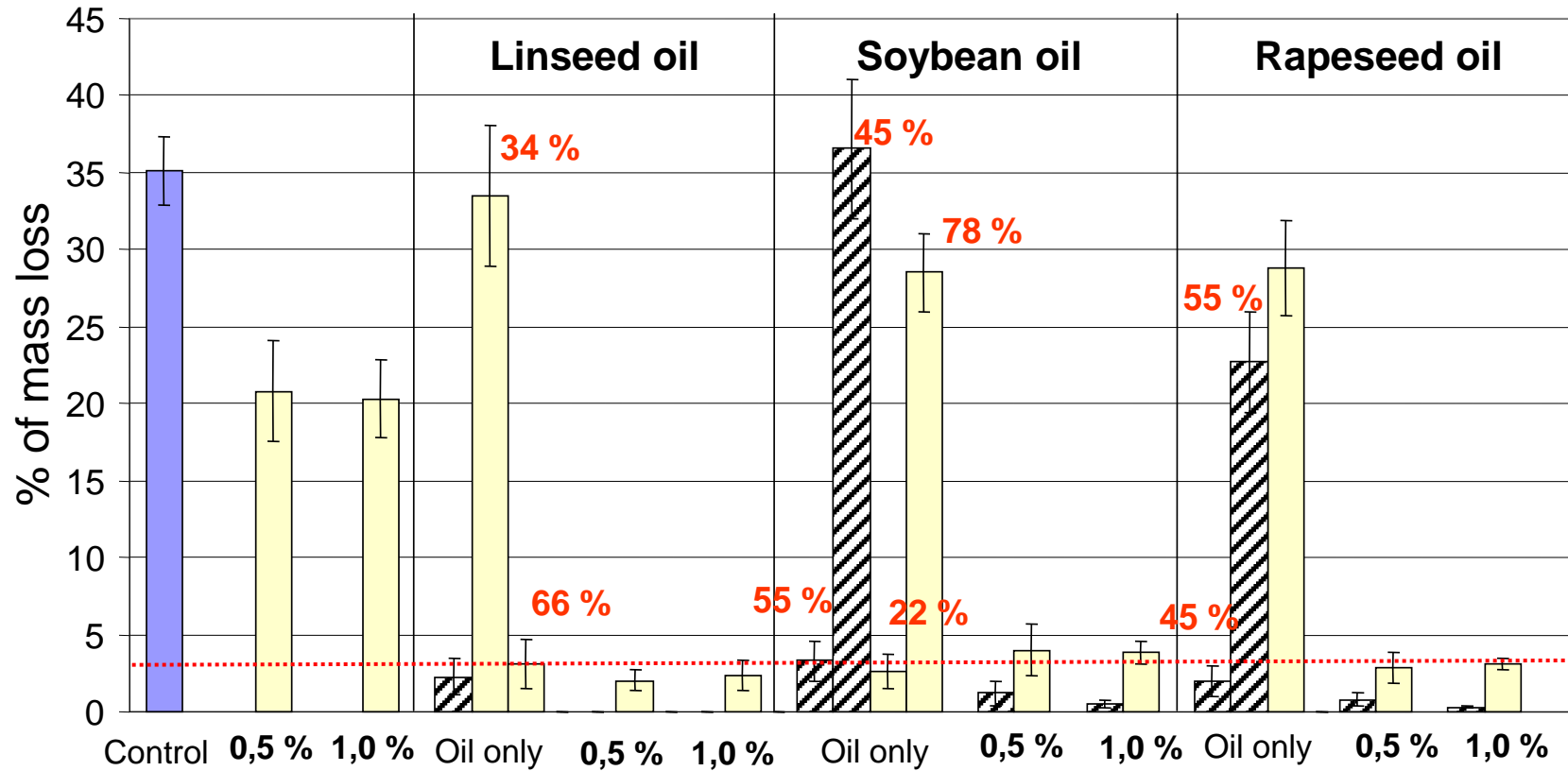
Results and discussion / Decay test



Mass losses of Japanese cedar sapwood specimens exposed to white rot fungus *Trametes versicolor*. Japanese standard method K 1571 (JIS 2004)

Control ■ Leached ■ unleached

Results and discussion / Decay test

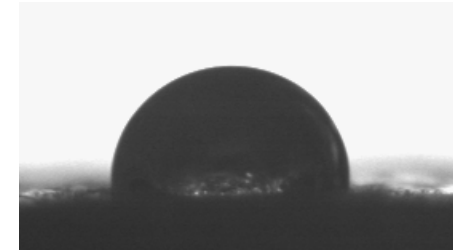
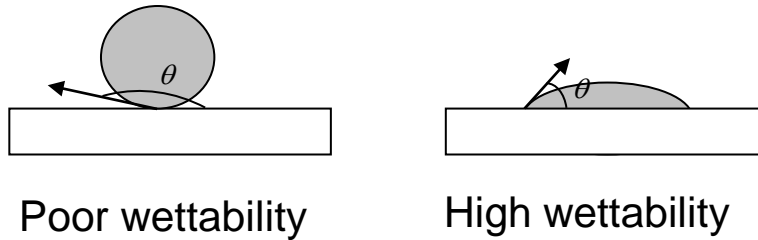


Mass losses of Japanese cedar sapwood specimens exposed to brown rot fungus *Fomitopsis palustris*.

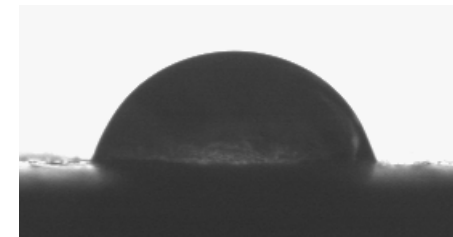
Japanese standard method K 1571 (JIS 2004)

Control ■ Leached ■ unleached

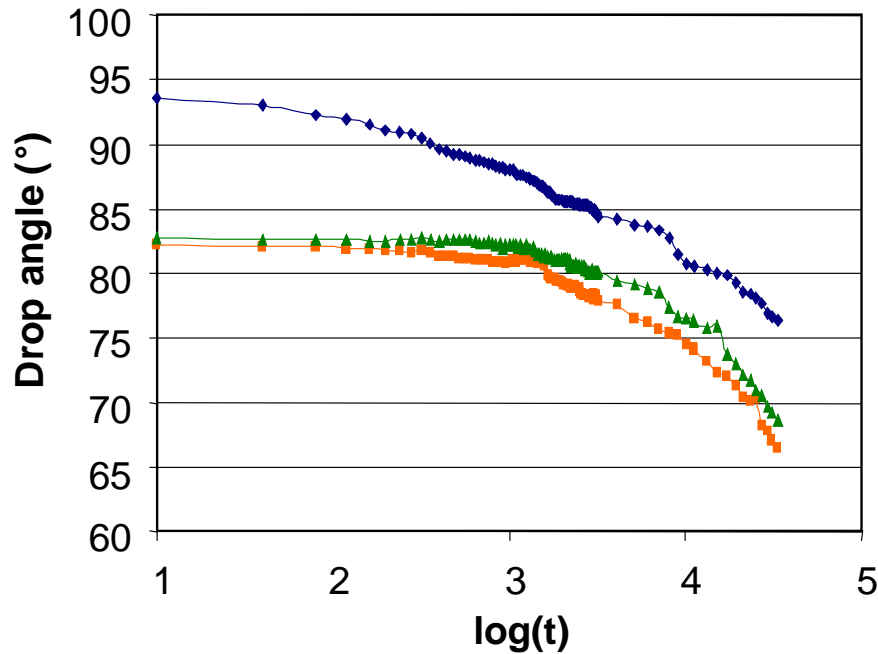
Contact angle measurement



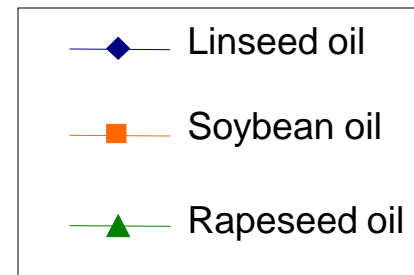
Linseed oil



Soybean oil



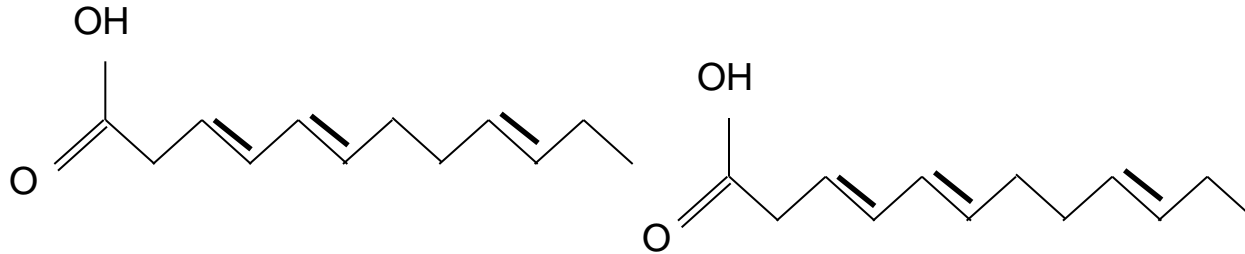
Evolution of water drop contact angle on different oiled surfaces



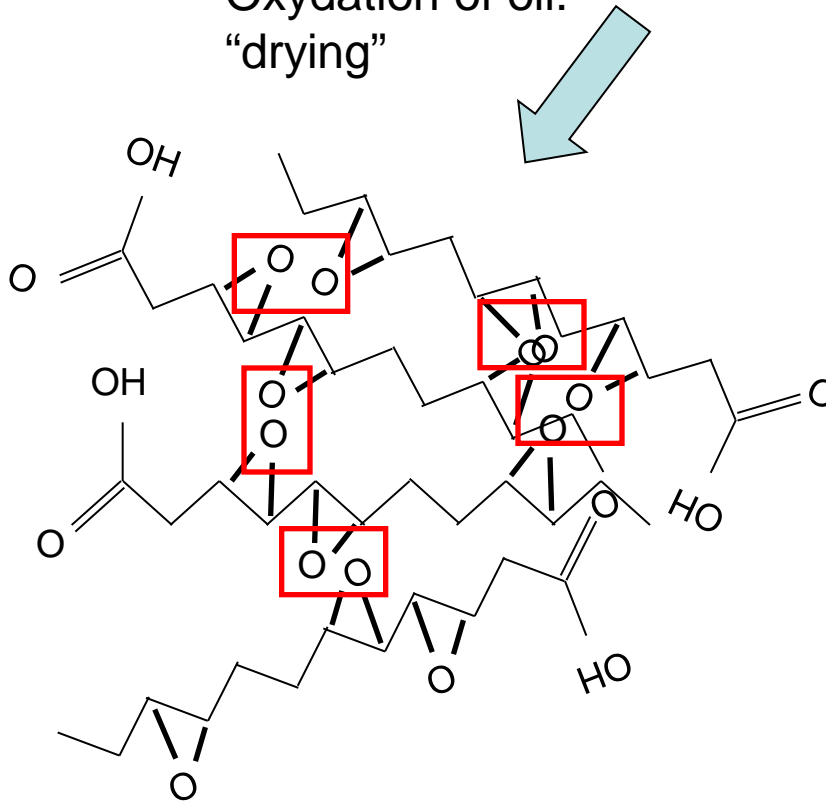
Conclusions

- Addition of linseed oil, soybean oil or rapeseed oil to boric acid treated wood increases boron retention of about 30 %.
- A combined vegetable oil/boric acid treatment is efficient against termites and decay fungi.
- Linseed oil is more efficient than soybean or rapeseed oil for boron retention and resistance to fungi.
- This combined treatment can be easily performed as an industrial process.

Contact angle measurement



Oxydation of oil.
“drying”



Fatty acids	Linseed oil	Soybean oil	Rapeseed oil
Linolenic acid (18 :3)	47.4	6.3	7.9
Linoleic acid (18 :2)	24.1	54.5	24.7
Polyunsaturated	71.5	60.8	32.6
Oleic acid (18 :1)	19.0	24.0	57.9
Stearic acid (18:0)	2.5	3.2	2.1
Palmitic acid (16 :0)	6.0	10.9	5.1
Mono-unsaturated and saturated	27.5	38.1	65.1
Total	99.0 %	98.9 %	97.8 %

Results / Termite test

<i>Cryptomeria Japonica</i> 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/m ³ 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

<i>Fagus Crenata</i> 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/m ³ 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)
	0.25 % / 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)	

Results /Decay test

<i>Cryptomeria Japonica</i> D.Don		Retention load of unleached samples (Kg/m ³ BAE) (1)	Boron retained after leaching (Kg/m ³ BAE) (2)	Mass loss by decay (%), mean (SD) (3)			
Treatment	Kg/m ³ BAE			<i>Trametes versicolor</i>		<i>Fomitopsis palustris</i>	
				Leached	Unleached	Leached	Unleached
L	-	-	-	0,28 (0,14)	0,66 (0,11)	3,08 (1,64) 66 % 33,5 (4,62) 34%	2,26 (1,19)
S	-	-	-	2,16 (0,33)	2,11 (0,52)	2,59 (1,09) 22% 28,5 (2,49) 78%	3,29 (1,31) 55 36,56 (4,49) 45%
R	-	-	-	3,61 (1,64)	3,95 (1,29)	28,8 (3,09)	1,99 (0,99) 45 22,72 (3,29) 55%
0.50 % control	4,02 (0,17)	0,00 (0,00)	0,00 (0,00)	25.7 (4.08)	0,00 (0,00)	20,8 (3,30)	0,00 (0,00)
0.50 % / L	4,01 (0,09)	0,76 (0,11)	0,76 (0,11)	2,30 (0,65)	0,00 (0,00)	2,03 (0,67)	0,00 (0,00)
0.50 % / S	3,94 (0,08)	0,81 (0,11)	0,81 (0,11)	3,29 (0,47)	1,05 (0,34)	3,98 (1,65)	1,19 (0,80)
0.50 % / R	3,88 (0,12)	0,97 (0,05)	0,97 (0,05)	4,13 (0,56)	1,92 (0,39)	2,81 (0,99)	0,76 (0,42)
1.00 % control	7,95 (0,19)	0,00 (0,00)	0,00 (0,00)	23.8 (2.70)	0,00 (0,08)	20,3 (2,53)	0,00 (0,00)
1.00 % / L	8,34 (0,17)	1,48 (0,09)	1,48 (0,09)	1,99 (0,51)	0,00 (0,00)	2,33 (1,01)	0,00 (0,00)
1.00 % / S	7,99 (0,11)	2,01 (0,14)	2,01 (0,14)	1,72 (0,64)	1,00 (0,53)	3,80 (0,74)	0,53 (0,24)
1.00 % / R	7,91 (0,15)	1,68 (0,15)	1,68 (0,15)	1,97 (0,88)	1,35 (0,43)	3,12 (0,39)	0,30 (0,10)
Untreated control				26,0 (3,51)		35,1 (2,20)	

Results /Decay test

<i>Fagus Crenata</i> Blume	Retention load of unleached samples (Kg/m ³ BAE) (1)	Boron retained after leaching (Kg/m ³ BAE) (2)	Mass loss by decay (%), mean (SD) (3)			
			<i>Trametes versicolor</i>		<i>Fomitopsis palustris</i>	
Treatment	Kg/m ³ BAE		Leached	Unleached	Leached	Unleached
L	-	-	9,64 (0,87)	7,03 (0,24)	3,76 (0,24) 20 % 30,7 (3,67) 80%	4,49 (0,30) 80% 31,7 (2,54) 20%
S	-	-	8,47 (0,82)	9,55 (0,14)	35,0 (2,15)	31,6 (4,24)
R	-	-	11,7 (0,58)	10,7 (0,84)	35,3 (2,34)	31,1 (2,81)
0.50 % control	3,22 (0,15)	0,00 (0,00)	48,8 (4,90)	1,84 (1,16)	28,1 (4,30)	1,12 (0,44)
0.50 % / L	3,12 (0,11)	0,63 (0,08)	7,45 (1,12)	1,46 (0,49)	14,7 (2,11)	2,36 (0,51)
0.50 % / S	2,94 (0,09)	0,39 (0,06)	8,40 (0,34)	4,29 (1,42)	35,2 (3,08)	0,97 (0,49)
0.50 % / R	3,29 (0,14)	0,58 (0,12)	7,21 (1,33)	2,29 (0,29)	22,0 (6,50)	1,94 (1,23)
1.00 % control	6,53 (0,21)	0,00 (0,00)	52,2 (4,61)	0,55 (0,21)	32,4 (2,50)	0,30 (0,21)
1.00 % / L	6,31 (0,14)	1,75 (0,15)	1,63 (0,12)	0,77 (0,15)	2,86 (1,43)	0,00 (0,00)
1.00 % / S	6,54 (0,10)	1,13 (0,09)	2,46 (0,11)	1,24 (0,43)	5,76 (1,79)	0,60 (0,55)
1.00 % / R	6,66 (0,11)	1,08 (0,07)	3,10 (0,55)	2,07 (0,67)	10,9 (1,59)	0,55 (0,22)
Untreated control			54,6 (8,40)		32,9 (5,87)	