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Preservation efficacy of pine wood tars

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Preface

This is a report of a joint Nordic project aimed at examining the preservation efficacy of Scots pine tar to support the theory that pine tar used as a wood surface treatment should not be considered as under the scope of the Biocidal Products Directive 98/8/EC.

The project was carried out by SP Swedish National Testing and Research Institute where the following persons are acknowledged: Linda Eriksson and her supervisor Dr Susanne Ekendal at SP Biolab at the department of Chemistry and Material Science who performed the sterile laboratory and fungal testing work and Dr Mats Westin at SP Trätek at the department of Building Technology and Mechanics Wood Technology who prepared the original report. Kati Suomalainen from the Finnish Environment Institute prepared the final report for publishing.

The project was supervised by the Nordic Biocides Group under the Nordic Chemicals Group. Christian Dons from the Norwegian Pollution Control Authority acted as a project leader and the following persons acted as a steering group for the project: Jørgen Larsen from the Danish Environmental Protection Agency, Sanna Kaukoniemi from the Finnish Environment Institute, Elin G. Gudmundsdottir from the Environment Agency of Iceland, Helena Casabona and Johan Helgesson from the Swedish Chemicals Inspectorate. The project was financially supported by the Nordic Council of Ministers, Danish Environmental Protection Agency and the Directorate for Cultural Heritage of Norway.

Summary

This joint Nordic project was initiated to examine the preservation efficacy of Scots pine tar and to support the theory that pine tar used as a wood surface treatment should not be considered as under the scope of the Biocidal Products Directive 98/8/EC.

Scots pine tar has been used for wood protection in the Nordic countries for over a millennium. Nowadays pine tar is in particular used on old traditional wooden buildings and structures and it is important for protection of cultural heritage in the Nordic countries.

Protective effectiveness of pine tar was assumed to be mainly attributed to the water repellency of the coating film and not to a fungicidal effect of the tar components. However, this theory was not proven in standard laboratory tests against wood decaying higher fungi (basidiomycetes) and there was no scientific evaluation of the efficacy of pine tars. It was unknown whether or not pine tar had a sufficient biocidal wood preservation efficacy to be defined as a biocidal product.

In the EU review program under the Biocidal Products Directive 98/8/EC (BPD) pine tar was considered as a biocidal active substance to be evaluated in the review program. Otherwise pine tar would not be allowed to be placed on the EU market after the 1st of September 2006.

As the use of pine tar is necessary for protection of old traditional wooden buildings and structures in the Nordic countries the Nordic Biocides Group under the Nordic Chemicals Group decided to initiate a study on the fungicidal efficacy of pine tar in order to clarify if pine tar has sufficient biocidal efficacy to fall under the Biocidal Products Directive.

Pine tar was studied in the European Standard test EN 113:1996 (*Wood preservatives – Test method for determining the protective effectiveness against wood destroying basidiomycetes*). Pine tar not passing the criteria of this test could not be authorised as biocidal product against bacidiomycetes but would be allowed to stay on the marked as a wood surface product (paints) without biocidal claims and so be outside the scope of BPD. In addition, as paints pine tar and pine tar containing products could still be used in protection of traditional wooden buildnings in the Nordic countries and the pine tar could still be placed on the market in the EU.

The test was conducted by SP Swedish National Testing and Research Institute. Ten different tar products from the Nordic countries were submitted to be tested on Scots pine sapwood pieces. Reference product was a common wood preservative for surface application was used together with a coating product with no fungicidal efficacy.

The test specimens were dipped in the tar products for 30 min followed by drying for 20 days in a ventilation cabinet with UV radiation. The coated test specimens were standing on one endgrain face on a nail mat and turned upside down every day during the drying period in order to ensure an even coating thickness. The samples were weighted after oven-drying at 103ºC for 18 h and then vacuum-impregnated with de-ionized water and left in water bottles for a 14 day period. During this 14 days period the water was changed 10 times. The samples were oven-dried and the mass loss due to leaching was calculated. After that the test specimens were put in small sealed jars and sterilized by gamma irradiation.

The test vessels were prepared according to the standard. A malt agar solution was inoculated with the three test mycelia (*Coniophora puteana*, *Gloeophyllum trabeum* and *Poria placenta)* and placed in the test vessels and inoculated for 2 weeks after which the test specimens and the corresponding control specimens were placed in the test vessels. The duration of the test was approximately 16 weeks. After this the test specimens were wiped clean from mycelium, weighed, oven-dried (18h in 103ºC) and weighted again. The moisture contents and mass loss values were calculated.

None of the tar products gave any resistance against *Poria placenta* according to the test criteria. Furthermore, none of them provided enough resistance against *Gloeophyllum trabeum* to be regarded as wood preservatives and thereby as a biocide according to the sections in the standard EN113 and prEN839 concerning interpretation of results. The criteria is that the average corrected mass loss should be below 3% and only one test specimen is allowed to have a mass loss higher than 3% but lower than 5% and with only superficial decay. On the other hand, in the test with *Coniophora puteana*, three tar products fulfilled the criteria for wood preservatives and one product came close. However, the most relevant test fungus in the test was *Gloeophyllum trabeum*, since this type of fungi is the most frequently occurring in the applications where pine tar products are mainly used – in roof and above ground application. Damage caused by *Coniophora puteana* (“cellar fungus”) is found in cellar locations (dark and close to ground) where pine tar products are seldom used and not recommended.

Hence the test indicated that none of pine tar products acted as a wood preservative by providing decay resistance to wood when applied as surface treatment for above ground application. Therefore, the author of the test, SP Swedish National Testing and Research Institute, recommended that pine tar should not be listed as a biocide under the Biocidal Products Directive 98/8/EC.

The Member States of EU agreed in March 2007 that pine tar - used as wood surface treatment - should not be regarded as an active substance within the meaning of Biocidal Products Directive 98/8/EC and that pine tar - used as wood surface treatment - does not fall under the scope of the Directive.

1. Background

Scots pine tar has been used for wood protection in the Nordic countries for over a millennium. Nowadays pine tar is in particular used on old traditional wooden buildings and structures and it is important for protection of cultural heritage in the Nordic countries.

It is believed that the protective effectiveness of pine tar is mainly attributed to the water repellency of the coating film and not to a fungicidal effect of the tar components. However, this theory was not proven in standard laboratory tests against wood decaying higher fungi (basidiomycetes) and there was no scientific evaluation of the efficacy of pine tars. In other words, it was not known whether or not the pine tar had a sufficient biocidal wood preservation efficacy to be defined as a biocidal product.

This question of pine tar having a sufficient fungicidal effect to be regarded as a wood preservative became very interesting when the evaluation of active substances in biocidal product type "wood preservatives" (PT8) in the EU review program under Biocidal Products Directive 98/8/EC (BPD) started in 2004. Pine tar (CAS no. 8011-48-1, EINECS no. 232-374-8) was identified in the review program as an existing active substance but it was not notified in the evaluation programme of the active substances in wood preservatives. That is to say, pine tar was considered as a biocidal active substance and should be evaluated in the review program if products containing pine tar could continue to be marketed in the future. Since pine tar is used in protection of objects of cultural and historical interest an essential use derogation was applied for according to the 3rd Review Regulation (1048/2005/EC) to allow products to be placed on the market in the EU after the 1st of September 2006.

As the use of pine tar is necessary for protection of old traditional wooden buildings and structures in the Nordic countries, the Nordic Biocides Group under the Nordic Chemicals Group decided to initiate a study on the fungicidal efficacy of pine tar in order to clarify whether pine tar has sufficient biocidal efficacy to fall under the Biocidal Products Directive or if the results show that pine tars do not have sufficient efficacy and would fall outside the scope of the Biocidal Products Directive.

According to the regulations pine tar should pass the criteria of the maximum mass loss of the test specimen in the European Standard test EN113:1996 (*Wood preservatives – Test method for determining the protective effectiveness against wood destroying basidiomycetes*). An active substance or a product not passing these criteria cannot be authorised as biocidal product against bacidiomycetes but would be allowed to stay on the marked as a wood surface product (paints) without biocidal claims and so be outside the scope of the BPD.

For pine tar and pine tar containing products not passing the criteria would mean that they could be considered as surface treatment products without biocidal efficacy and be outside the scope of BPD. In addition, pine tar and pine tar containing products could still be used in protection of traditional wooden buildnings in the Nordic countries and the pine tar could still be placed on the market in the EU.

Consequently, the Nordic Biocides Group commissioned SP Swedish National Testing and Research Institute to conduct the test to assess if pine tar had a sufficient biocidal effect against wood decaying fungi. The testing was done according to EN113:1996; *Wood preservatives – Test method for determining the protective effectiveness against wood destroying basidiomycetes*, using the option with surface coating instead of vacuum/pressure impregnation which corresponds to the pre-standard ENV 839:2006 and results are represented in the following technical report from the test.

2. Materials and Methods

2.1 Wood Material

The wood material used was Scots pine sapwood (*Pinus sylvestris* L.) from Unnared sawmill in southern Småland. Test specimens, 15x25x50mm, were sawn out from the larger boards. The average density was 535 kg/m³ and the annual year ring width was within the limits given in the standard.

2.2 Wood tar products

Retorte 1:	Swedish product	**Kiln tar 2**:	early fraction
Retorte 2:	Norwegian product	**Kiln tar 3**:	intermediate fraction
Retorte 3:	Finnish product	**Kiln tar 4**:	late fraction
Retorte 4:	Swedish product	**Kiln tar 5**:	Swedish product
Kiln tar 1:	Danish product	**Kiln tar 6**:	Finnish product (Finnish tar)

Retorte 4 coated church roof shingle: Tar-coated and stored 12 years (see next page for more information)

All included tar products consists of 100% pine tar according to the suppliers and no information concerning differences in chemical composition between the different products have been given. However, information were given that the wood source for the different tar products were different – e.g. Retorte 1 and 2 are produced from Chinese pine species whereas Retorte 4 is produced from Scandinavian-grown Scots pine. It was hinted by one of the producers that Chinese tars were also used in some of the Kiln tar products. It generally seems like the kiln tars contains more volatile components than the retorte tars and that the color of the kiln tars is lighter brown.

2.3 Reference products

Beckers träskydd grön: Copper-naphthenate (approx 40%) in white spirit. A common wood preservative used for surface application. Producer: Becker-Acroma, Sweden.
Servalac: Example of a coating product with no fungicidal efficacy. Servalac is a two-component polyurethane coating. Producer: Alcro-Becker, Sweden.

2.3 Coating of test specimens

It was decided not to endgrain seal the test specimens before coating with the tar products since an important function of the tar products is as end-grain sealant. Several pre-trials of coating according to the recommendations by the manufacturers led to that two layers of brushing, with an intermediate drying step under UV radiation, gave approximately the same grammage (amount of product per square meter) as dipping in tar for 30min at room temperature. On end-sealed specimens this meant approximately 150 g/m² and on non-endgrain sealed specimens 220 g/m². It was therefore decided to use dipping in tar at room temperature for all tar products.

2.3.1 Coating with tar products

The test specimens were dipped in tar product (at 22ºC) for 30 min followed by drying for 20 days in a ventilation cabinet with UV radiation. The coated test specimens were standing on one endgrain face on a nail mat and turned upside down every day during the drying period in order to ensure an even coating thickness. The average coating amount for each coating product is shown in table 1 and the exact coating amount for each test specimen is shown in Appendix 1 and 2.

Figure 1. Drying of tar-coated test specimens in ventilation cabinet with UV-light.

Figure 2. EN 113 vessels in test.

Roof shingle

In the summer of 1994, the church roof shingle (cleaved type, from fresh non-weathered pine timber), was coated with retorte tar No.4 by single dipping in warm tar (50-60ºC) which resulted in tar penetration depth of 1-2mm except for end-grain surfaces with 5-6mm penetration depth. The tar-coated shingles were dried out-doors for a month and were thereafter stored in a church tower (dark and dry conditions) until October 2005, i.e. 11 years of storage. Test specimens with approximately the same volume as the other test specimens were cut from the tar-coated roof shingle. Since, the sawn surfaces were non-coated by tar these surfaces were sealed with two coats of Servalac (for more information about the sealing, see next section).

2.3.2 Coating of reference

Dipping for 30min in the reference preservative, which resulted in 101 g/m². For the non-biocidal reference coating (white polyurethane paint, Servalac, from Alcro-Becker), brushing in two layers was applied, which lead to a total coating amount of 148 g/m².

2.4 Test fungus strains

- ***Coniophora puteana*** (Schumacher ex Fries) Karsten (BAM Ebw. 15)
- ***Gloeophyllum trabeum*** (Persoon ex Fries) Murrill (BAM Ebw. 109)
- ***Poria placenta*** (Fries) Cooke sensu J. Eriksson (FPRL 280) (*Postia placenta* in AWPA nomenclature)

2.5 Accelerated aging (water leaching) according to EN 84

The samples were weighted after oven-drying at 103ºC for 18h. The samples (each group separately) were vacuum-impregnated with de-ionized water and left in water bottles (water amount 5:1 based on sample volume). The water was changed 10 times during a 14 days period. The samples were oven-dried and the mass loss due to leaching was calculated.

2.6 Sterilization of test specimens

The test specimens were put in small sealed jars – one jar for each specimen. The test specimens (in the jars) were sterilized by gamma irradiation (min 25kGy) at IFE (the Norwegian Institute for Energy Technology).

2.7 Testing according to ENV839:2006/ EN113

2.7.1 Test vessel and test specimen preparation and sterilization

The test specimens (15x25x50mm) were conditioned at 20ºC, 85% RH. Autoclavable plastic vessels with screw-lids according to EN113 standard, Annex C, figure C.3 (600ml, Ø=90mm), were dish-washed and cotton plugs were put in the center hole (Ø=20mm) of the lids. Round plastic nets (Ø=80mm) with a center hole (Ø=20mm) were prepared. The malt agar solution was prepared according to the standard. The nets were put in the sealed autoclave filter bags. The vessels, lids, bags and agar solution bottles were steam sterilized for 20min at 121ºC. After sterilization, when still warm, the agar solution was poured into each vessel to an approximate height of 8mm, thereafter the lids were screwed on.

2.7.2 Inoculation of the test vessels

An inoculum from mycelium-overgrown agar petri-dishes (2-3 weeks after inoculation of the agar in the petri-dishes) was placed on the agar in the center hole of the net.

2.7.3 Duration and termination of the test

According to the standard, the inoculation period was 2-4 weeks, after which one test specimen and its corresponding control specimen were placed on the net (on top of the agar), one on each side of the center hole for each test vessel. The duration of the test was approx. 16 weeks. The vessels were inoculated the 22/12-2005, the test specimens introduced the 5/1-2006 and the test terminated the 15/5-2006. After this time the test specimens were wiped clean from mycelium, weighed, oven-dried (18h in 103ºC) and weighted again. The moisture contents and mass loss values were calculated.

3. Results and Discussion

3.1 Mass loss due to EN 84 leaching (prior to fungal decay test)

This leaching removes non-fixed water-soluble compounds that would otherwise have influenced the fungal test. The mass loss of the tar coated specimens were between 1 and 2%, except for Retorte 1 coated specimens that had mass loss values between 7 and 8% (see Appendix 2). However, there may be volatile low-molecular compounds in tar products that are not water soluble.

3.2 Visual observations during the test

3.2.1 Infection by non-target organisms

For non-inocculated vessels only very few were infected (5 out of 34), but the minor infections had no effect on the correction value. No vessels inoculated with *Poria* had any infections and only one vessel (out of 77) inoculated with *Gloeophyllum* was infected with mould, but in a late stage so that the mass loss value for the specimen was no different than the value for the other samples in the group. Of the 77 vessels inoculated with *Coniophora*, 16 were infected with mould, but in a late stage so that the mass loss values were not much affected except for the virulence control vessels which were all infected and had lower mass loss values than the average value for *Coniophora* on controls.

3.2.2 Virulence

All test fungus species seemed to be virulent and especially *Poria* looked very virulent (see Figure 3).

Figure 3. EN 113 vessels after test. Poria placenta on the left, Coniophora puteana in the middle and Gloeophyllum trabeum on the right.

Visual inhibition of mycelium growth by some treatments

None of the treatments caused visual inhibition of *Poria*. For *Coniophora* no treatment seemed to cause inhibition. However, for *Gloeophyllum* some treatments caused visible inhibition: these were the reference biocide (Beckers träskydd grön) which caused a total inhibition, kiln 4 which seemed to cause a strong inhibition, all other kiln tars seemed to cause slight inhibition and finally retorte No 4 which also seemed to cause slight inhibition. The other retort tars did not seem to cause any inhibition and the old roof shingle coated with retorte 4 and then stored did not seem to inhibit the *Gloeophyllum* mycelium growth.

Figure 4. Treatments that seemed to cause strong inhibition of Gloeophyllum mycelium growth. Copper-naphthenate reference on the left, Kiln tar 4 in the middle and Retorte tar 4 on the right.

Figure 5. Treatments that seemed to cause slight inhibition of Gloeophyllum mycelium growth. Kiln tar 1 on the left, Kiln tar 2 in the middle and Kiln tar 3 on the right.

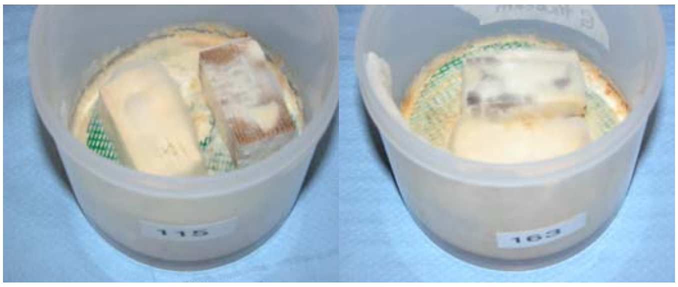

Figure 6. Further treatments that seemed to cause slight inhibition of Gloeophyllum mycelium growth. Kiln tar 5 on the left and Kiln tar 6 on the right.

Figure 7. Treatments that did not seem to cause any inhibition of Gloeophyllum mycelium growth. Retorte tar 1on the left, Retorte 2 in the middle and Retorte 3 on the right.

Figure 8. Further treatments that did not seem to cause any inhibition of Gloeophyllum mycelium growth. Retorte 4 coated roof shingle on the left and Servalac on the right.

3.4 Correction value (from non-inoculated vessels)

The changes in oven-dry weight (correction mass loss) of the non-inoculated specimens were, as expected, very small (cf. Table 1). The values for individual specimens are shown in Annex 1.

Table 1. Calculation of correction values (mass change in non-inoculated vessels stored for 16 weeks in the fungal culture room). Average values for each group.

Coating type	Product amount applied (g/sample)	Product amount applied (g/m²)	Oven-dry weight after EN84 leaching (g)	Moist weight after 16 weeks** (g)	Oven-dry weight after 16 weeks** (%)	Moisture content after 16 weeks** (%)	Correction value (ML after 16 weeks) (%)
None (control)			**9,2614**	**12,8355**	**9,8373**	**30,50**	1,80
Reference preservative (Copper-nahpthenate)	**0,48**	**101**	**8,9544**	**11,5530**	**8,9056**	**29,70**	0,55
Reference non-biocidal coating (Servelac)	**0,68**	**142**	**9,9174**	**12,6513**	**9,8937**	**27,78**	0,26
Tar products							
Retorte 1	**1,03**	**217**	**9,0604**	**11,6332**	**9,0524**	**28,43**	0,09
Retorte 2	**1,17**	**246**	**9,7822**	**12,3083**	**9,7345**	**26,36**	0,49
Retorte 3	**1,16**	**243**	**9,8532**	**12,3646**	**9,8260**	**25,75**	0,28
Retorte 4	**0,76**	**159**	**9,1772**	**11,7004**	**9,1474**	**27,87**	0,33
Kiln 1	**1,22**	**257**	**9,5852**	**12,0753**	**9,5553**	**26,31**	0,32
Kiln 2	**1,14**	**240**	**9,9976**	**13,0757**	**9,9295**	**31,91**	0,71
Kiln 3	**1,08**	**228**	**9,5486**	**12,1824**	**9,4976**	**28,26**	0,54
Kiln 4	**1,01**	**214**	**9,8374**	**12,4744**	**9,8131**	**27,09**	0,25
Kiln 5	**1,21**	**255**	**9,9606**	**12,5930**	**9,9274**	**26,80**	0,43
Kiln 6	**1,01**	**213**	**9,5838**	**12,1035**	**9,5587**	**26,54**	0,26
Retort 4 coated roof shingle	**0,18***	**?**	**9,8998**	**12,6658**	**9,8654**	**28,44**	0,35

* sealing of sawn surfaces with Servalac
** in non-inoculated vessels stored in the culture room

The highest correction value was 1.80% mass loss for the untreated pine sapwood control specimens and the lowest was 0.09% for specimens coated with retorte tar 1.

3.5 Virulence test of the test fungi (with only control specimens in the vessels)

As can be seen in table 2, all test fungus strains passed the criteria of causing over 20% mass loss. *Coniophora* causing a mean mass loss of 33,5% to the control specimens, *Gloeophyllum* 25,6% and *Poria* 40,1%.

However, one should have in mind that having two control specimens in the same vessel usually results in lower mass loss values for the controls than having only one control specimens (and one treated) as in the case of the rest of the test vessels.

Table 2. Virulence control test specimens; mass loss in percentage.

Test fungi (Timber)	Oven-dry weight after EN84 leaching (g)	Oven-dry weight after test (g)	Uncorrected individual mass loss (%)	Corrected individual mass loss (%)	Mean mass loss (%)	Minimum required by the standards (%)
Coniophora puteana (Scots pine)	**8,8170 7,4070 10,2220 10,0390 7,6940**	**5,1611 4,4633 6,8657 7,3186 4,9897**	**41,46 39,74 32,83 27,10 35,15**	**39,66 37,94 31,03 25,30 33,35**	33,5	**20,0**
Gloeophyllum trabeum (Scots pine)	**9,6400 10,3980 9,1040 8,7060 9,9770 10,1280**	**7,1351 7,9031 6,6695 6,5820 6,7043 7,0396**	**25,98 23,99 26,74 24,40 32,80 30,49**	**24,18 22,19 24,94 22,60 31,00 28,69**	25,6	**20,0**
Poria placenta (Scots pine)	**9,3830 9,2680 8,0060 10,1120 9,9420 9,7090**	**5,1640 4,7919 4,4275 6,0132 6,2877 6,1805**	**44,96 48,30 44,70 40,53 36,76 36,34**	**43,16 43,50 42,90 38,73 34,96 34,54**	40,1	**20,0**

3.6 Mass loss in inoculated vessels

3.6.1 Brown rot type 1: Coniophora puteana (obligatory in EN113/prEN 839)

Table 3 shows average values for each group of specimens, the results for each individual test specimen can be found in Appendix 2.

Table 3. Mass loss due to decay by Coniophora puteana in prEN 839/EN 113 test, 16 weeks exposure

Treatment type	Product amount applied (g/m^2)	Corrected mass loss (in %) by fungal decay			
		Coated		Controls	
Tar products					
Retorte 1	**237**	36,10	**± 8,64**	**39,56**	**±12,51**
Retorte 2	**239**	25,92	**± 10,28**	**44,04**	**± 8,66**
Retorte 3	**231**	13,18	**± 6,94**	**44,88**	**±12,46**
Retorte 4	**163**	0,51	**± 0,16**	**47,00**	**± 7,21**
Kiln 1	**253**	10,18	**± 7,93**	**45,06**	**± 6,20**
Kiln 2	**240**	5,95	**± 10,46**	**43,10**	**± 7,71**
Kiln 3	**229**	3,42	**± 4,50**	**50,90**	**± 1,52**
Kiln 4	**223**	1,51	**± 0,80**	**48,30**	**± 5,46**
Kiln 5	**228**	2,54	**± 1,31**	**48,53**	**± 9,56**
Kiln 6	**184**	1,45	**± 0,43**	**51,09**	**± 6,56**
Retorte 4 coated roof shingle	**-**	27,62	**± 4,58**	**31,69**	**± 5,35**
Reference preservar-tive (Copper-nahptenate)	**97**	0,10	**± 0,04**	**41,25**	**± 5,82**
Reference non-biocidal coating (Servalac)	**154**	32,83	**± 11,67**	**40,78**	**±13,56**
Average ML for controls				**45,01**	**± 9,02**

The mass loss (ML) of untreated controls was between 21 and 61% for individual specimens with an average of 45% and between 32 and 51% for each group (see Table 2, right column).

In order to be approved as a wood preservative for surface application the average corrected ML of the test group should be less than 3% and only one specimen is allowed to have a ML higher than 3% but lower than 5%. This criteria is of course fulfilled by the reference preservative (Beckers träskydd grön with Copper-naphthenate as active biocide) with no sign of decay, 0% ML. The specimens treated with the non-biocidal reference coating (Servalac) on the other hand were all decayed with an average of 33% ML. The specimens coated with retorte tars 1 and 2 were all severely decayed with average ML values of 36 and 26%, respectively. Retorte 3 coated specimens were also decayed but everything from slight to severe decay with an average ML of 13% but no individual specimen with a ML lower than 3%. Three Kiln 1 coated specimens were severely decayed but the other two had very low ML (<3%). Kiln 2 and Kiln 3 coated specimen groups, each had one severely decayed specimen whereas the other were practically sound with 4 and 3 specimens below 3% ML each. Kiln 5 coated specimens all had low ML values, 3 below 3% and 2 between 3 and 5%.

Three tar products fulfilled the criteria as wood preservative based on the *Coniophora* results, Kiln 4, Kiln 6 and Retorte 4 coated specimens all had ML values below 3%. However, the specimens taken from the old church roof shingle coated with Retorte 4 twice and then stored for a long period (several years) in the church tower, were all severely decayed with high ML values as result. This shows that the same product that had high anti-fungal effect when testing freshly treated specimens had no anti-fungal effect after storage of the coated wood. Furthermore, the roof shingle partly consisted of pine heartwood which normally would have reduced the ML values somewhat, but still they were high.

3.6.2 Brown rot type 2: Gloeophyllum trabeum (Optional additional test fungus in EN113)

The mass loss (ML) of untreated controls was between 22 and 54% for individual specimens with an average of 38% and between 26 and 46% for each group (see Table 4, right column).

Table 4. Mass loss due to decay by *Gloeophyllum trabeum* in EN113, 16 weeks exposure

Treatment type	Product amount applied (g/m^2)	Corrected mass loss (in %) by fungal decay			
		Coated		Controls	
Tar products					
Retorte 1	**211**	29,68	**± 1,43**	**26,36**	**± 4,08**
Retorte 2	**209**	32,63	**± 2,12**	**33,65**	**± 3,46**
Retorte 3	**222**	27,05	**± 2,91**	**28,25**	**± 3,46**
Retorte 4	**157**	5,03	**± 2,76**	**45,60**	**± 9,80**
Kiln 1	**257**	5,50	**± 1,30**	**41,01**	**± 3,32**
Kiln 2	**241**	9,29	**± 5,45**	**45,49**	**± 5,00**
Kiln 3	**217**	11,06	**± 7,60**	**43,55**	**± 5,19**
Kiln 4	**223**	6,38	**± 6,89**	**46,08**	**± 5,70**
Kiln 5	**243**	5,31	**± 2,19**	**38,85**	**± 7,96**
Kiln 6	**202**	19,54	**± 9,04**	**43,15**	**± 5,66**
Retorte 4 coated roof shingle	**-**	32,50	**± 3,52**	**33,35**	**± 6,78**
Reference preservartive (Copper-nahptenate)	**105**	0,22	**± 0,08**	**35,42**	**± 5,13**
Reference non-biocidal coating (Servalac)	**147**	25,59	**± 2,67**	**32,03**	**± 6,57**
Average ML for controls				**38,23**	**± 9,14**

With *Gloeophyllum* only the reference wood preservative fulfills the criteria. All 5 samples treated with copper-naphthenate were sound with practically zero ML values. None of the groups of tar coated samples had ML average values below 5%, although a few individual specimens coated with Kiln 4 (2 samples with 2,5 and 2,3% ML, respectively), Kiln 5 (1 sample with 2,8% ML) and Kiln 6 (1 sample with 0,3% ML) had ML values below 3%. As with *Coniophora* the lowest average ML value by *Gloeophyllum* was for the specimens coated with Retorte 4 (5.03 %) but also once again, the roof shingle coated with Retorte 4 had high ML values, close to the values for controls, indicating that volatile components in the freshly coated specimens initially causes some inhibition.

3.6.3 Brown rot type 3: Poria placenta (optional complementing test fungus)

The mass loss (ML) of untreated controls was between 32 and 57% for individual specimen with an average of 44% and between 39 and 53% for each group (see Table 5, right column).

Table 5. Mass loss due to decay by Poria placenta in EN113, 16 weeks exposure

Treatment type	Product amount applied (g/m²)	Corrected mass loss (in %) by fungal decay			
		Coated		Controls	
Tar products					
Retorte 1	**217**	27,63	**± 1,12**	**40,28**	**± 5,62**
Retorte 2	**185**	27,08	**± 2,79**	**44,29**	**± 5,60**
Retorte 3	**194**	26,76	**± 5,84**	**38,80**	**± 5,98**
Retorte 4	**138**	23,71	**± 3,00**	**50,57**	**± 5,22**
Kiln 1	**225**	28,74	**± 2,31**	**44,20**	**± 5,66**
Kiln 2	**213**	29,06	**± 3,93**	**40,60**	**± 2,98**
Kiln 3	**188**	28,16	**± 3,09**	**38,88**	**± 3,17**
Kiln 4	**211**	25,04	**± 4,14**	**39,63**	**± 4,36**
Kiln 5	**216**	28,13	**± 2,31**	**42,59**	**± 3,74**
Kiln 6	**180**	27,12	**± 2,47**	**38,98**	**± 3,77**
Retorte 4 coated roof shingle	**-**	21,90	**± 2,88**	**39,07**	**± 3,51**
Reference preservartive (Copper-nahptenate)	**100**	7,87	**± 5,94**	**53,08**	**± 2,30**
Reference non-biocidal coating (Servalac)	**150**	38,42	**± 3,80**	**40,68**	**± 2,26**
Average ML for controls				**43,57**	**± 6,71**

3.7 General discussion of results from all test fungi

Table 6. Compilation of mass loss due to decay by *basidiomycetes* in EN 113 test, 16 weeks exposure.

Treatment type	Product amount applied (g/m²)	Corrected mass loss (in %) by fungal decay											
		Coniophora puteana				*Gloeophyllum trabeum*				*Poria placenta*			
		Coated		Controls		Coated		Controls		Coated		Controls	
Tar products													
Retorte 1	**221**	36,10	**± 8,64**	**39,56**	**±12,51**	29,68	**± 1,43**	**26,36**	**± 4,08**	27,63	**± 1,12**	**40,28**	**± 5,62**
Retorte 2	**220**	25,92	**±10,28**	**44,04**	**± 8,66**	32,63	**± 2,12**	**33,65**	**± 3,46**	27,08	**± 2,79**	**44,29**	**± 5,60**
Retorte 3	**223**	13,18	**± 6,94**	**44,88**	**±12,46**	27,05	**± 2,91**	**28,25**	**± 3,46**	26,76	**± 5,84**	**38,80**	**± 5,98**
Retorte 4	**248**	0,51	**± 0,16**	**47,00**	**± 7,21**	5,03	**± 2,76**	**45,60**	**± 9,80**	23,71	**± 3,00**	**50,57**	**± 5,22**
Kiln 1	**154**	10,18	**± 7,93**	**45,06**	**± 6,20**	5,50	**± 1,30**	**41,01**	**± 3,32**	28,74	**± 2,31**	**44,20**	**± 5,66**
Kiln 2	**233**	5,95	**±10,46**	**43,10**	**± 7,71**	9,29	**± 5,45**	**45,49**	**± 5,00**	29,06	**± 3,93**	**40,60**	**± 2,98**
Kiln 3	**215**	3,42	**± 4,50**	**50,90**	**± 1,52**	11,06	**± 7,60**	**43,55**	**± 5,19**	28,16	**± 3,09**	**38,88**	**± 3,17**
Kiln 4	**218**	1,51	**± 0,80**	**48,30**	**± 9,76**	6,38	**± 6,89**	**46,08**	**± 5,70**	25,04	**± 4,14**	**39,63**	**± 4,36**
Kiln 5	**236**	2,54	**± 1,31**	**48,53**	**± 6,56**	5,31	**± 2,19**	**38,85**	**± 7,96**	28,13	**± 2,31**	**42,59**	**± 3,74**
Kiln 6	**194**	1,45	**± 0,43**	**51,09**	**± 6,56**	19,54	**± 9,04**	**43,15**	**± 5,66**	27,12	**± 2,47**	**38,98**	**± 3,77**
Retorte 4 coated roof shingle	**-**	27,62	**± 4,58**	**31,69**	**± 5,35**	32,50	**± 3,52**	**33,35**	**± 6,78**	21,90	**± 2,88**	**39,07**	**± 3,51**
Reference preservartive (Copper-nahptenate)	**101**	0,10	**± 0,04**	**41,25**	**± 5,82**	0,22	**± 0,08**	**35,42**	**± 5,13**	7,87	**± 5,94**	**53,08**	**± 2,30**
Reference non-biocidal coating (Servalac)	**148**	32,83	**±11,67**	**40,78**	**±13,56**	25,59	**± 2,67**	**32,03**	**± 6,57**	38,42	**± 3,80**	**40,68**	**± 2,26**
Average ML for controls				**45,01**	**± 9,02**			**38,23**	**± 9,14**			**43,57**	**± 6,71**

None of the tar products gave any resistance against *Poria placenta*. Furthermore, none of them provided enough resistance against *Gloeophyllum* *trabeum* to be regarded as wood preservatives and thereby biocide according to the sections in the standard EN113 and prEN839 concerning interpretation of results (the criteria is that the average corrected ML should be below 3% and only one test specimen is allowed to have a ML higher than 3% but lower than 5% and with only superficial decay). This is further elaborated in the German standard RAL-GZ 830 (Güte- und Prüfbestimmungen für Holzschutzmittel) where it is stated that a product intended for use as a wood preservative could not be regarded as a biocide if the mass loss values in tests according to EN113 or prEN839 are higher than 5%.

On the other hand, in the test with *Coniophora puteana*, three tar products (Kiln 4, Kiln 6 and Retorte 4) actually fulfilled the criteria for wood preservatives, one product (Kiln 5) came close, four products (Kiln 1, Kiln 2, Kiln 3 and Retorte 3) gave some slight but insufficient decay resistance and finally, two products (Retorte 1 and 2) gave no decay resistance at all.

The lowest average mass loss values with all three test fungi were obtained with specimens coated with Retorte 4. However, the complementing sets of test specimens taken from a church roof shingle coated twice with the “most efficient” tar product, Retorte 4, but cut after the coated shingle had been stored for a longer period in the church tower, were all severely decayed (in the same magnitude of decay as specimens coated with the non-biocidal reference coating). According to the producer, Retorte 4 has been identically produced for decades. This clearly illustrates that this tar product gives a decay resistance only in a initial phase where some volatile tar components have not yet evaporated.

The producer of Retorte 4 does not appreciate the label “retorte tar” since the process is not exactly the same as for a traditional retorte tar. The producer of retorte 4 agrees that this product probably contains more volatile compounds than the other “retorte tars”. However, in this report all industrially produced tars, i.e. not produced in a traditional forest kiln (Sw: *mila*, No/Da: *mile*), have been called retorte tars.

Generally, it seems (subjective observation, since no analytical data were given to SP) like the kiln tars contains more volatile components than the Retorte tars, which is logical since it should be easier to collect a more specific in a retorte process.

A higher content of volatile components in the kiln tars would explain the slight inhibition of decay by both *Coniophora* and *Gloeophyllum* when testing freshly treated wood specimens (in analogy with freshly retort 4 treated) compared with specimens treated with retorte tars 1-3. A accelerated ageing of all tar-coated specimens according to EN73 (evaporation of volatile compounds in a wind tunnel) prior to the decay test would probably have resulted in performance closer to the case with the stored roof shingle, i.e. very little or no decay resistance.

Furthermore, the most relevant test fungus in the test is *Gloeophyllum trabeum,* since this type of fungi is the most frequently occurring in the applications where pine tar products are mainly used – in roof and above ground application. Damages caused by *Coniophora puteana* ("cellar fungus") are found in cellar situation (dark and close to ground) where pine tar products are seldom used and not recommended.

The conclusion is therefore that the test indicates that none of pine tar products acts as a wood preservative by providing decay resistance to wood, when applied as surface treatment for above ground application.

3.8 Concluding remarks

The tests results presented in this report support the theory that pine tar products, which have been used over centuries for protection of wood in façade and roof situation, does not act as fungicides. The protection is more likely obtained by the tars acting as water-repellent coatings (however, water-repellency tests were not included in this test scheme).

The results indicate that the decay resistance obtained by coating wood with pine tar is nonexistent or insignificant. Therefore, it is recommended that pine tar should not be listed as a biocide by the Biocidal Products Directive 98/8/EC (BPD).

4. Fate of pine tar used as wood surface treatment in the Biocidal Products Directive 98/8/EC

At the 24th meeting of Competent Authorities (CA) for biocides Norway presented the results of this study with an overall conclusion of *"none of pine tar products acts as a wood preservative by providing decay resistance to wood, when applied as surface treatment for above ground application"*.

The Member States agreed in March 2007 that pine tar - used as wood surface treatment - should not be regarded as an active substance within the meaning of the Biocidal Products Directive 98/8/EC and that pine tar - used as wood surface treatment - does not fall under the scope of the Directive.

Sammandrag

Syftet med denna undersökning var att studera effektiviteten hos talltjära som trädskyddsmedel och stödja teorin att talltjära som används som ytbehandlingsmedel inte kan anses ingå i biociddirektivets 98/8/EG tillämpningsområde.

Tjära har använts som träskyddsmedel i de nordiska länderna under mer än 1000 år. Idag används tjära särskilt för att bevara traditionella byggnader och andra konstruktioner av trä. Talltjära är mycket viktig för skyddet av kulturarvet i de nordiska länderna.

Skyddseffektiviteten hos talltjära antas bero på den vattenavstötande hinnan som tjäran bildar och inte på den fungicida effekten av de olika verksamma ämnena i tjäran. Detta hade man dock inte påvisat i standard laboratorietester för trädnedbrytande svampar (basidomycetes) och det fanns inte heller någon vetenskaplig evaluering av talltjärans effektivitet. Det var inte fastslaget om talltjäran hade en tillräcklig biocid träskyddande effekt för att kallas en biocidprodukt.

I biociddirektivets (98/8/EG) översynsprogram betraktades talltjära som ett verksamt ämne med biocid effekt och den skulle evalueras enligt översynsprogrammet. I annat fall skulle talltjäran inte släppas ut på den europeiska marknaden efter den 1 september 2006.

Eftersom användning av talltjära är nödvändig för skydd av traditionella byggnader och andra konstruktioner av trä i de nordiska länderna beslöt biocidgruppen under Nordiska kemikaliegruppen att starta en studie av den fungicida verkan hos talltjära för att klarlägga om talltjäran hade en tillräcklig biocid effekt för att falla inom biociddirektivets tillämpningsområde.

Talltjäran studerades med en standardtest EN 113:1196 (*Wood preservatives – Test method for determining the protective effectiveness against wood destroying basidiomycetes*). Om tjäran inte fyllde testets kriterier skulle den inte anses som en biocid produkt mot basicomycetes. I så fall skulle tjäran förbli på marknaden som ett ytbehandlingsmedel för trä (målarfärg) utan biocida verksamma ämnen och falla utanför biociddirektivets ramar. Som målarfärg skulle talltjära och produkter som innehåller tjära fortfarande nyttjas i skyddet av traditionella träbyggnader i de nordiska länderna samt släppas ut inom EU marknad.

Studien genomfördes av SP Sveriges Tekniska Forskningsinstitut. Tio olika tjärprodukter från de nordiska länderna testades på stycken av furu. Som referensprodukter användes ett allmänt träskyddsmedel för ytbehandling samt ett ytbehandlingsmedel utan fungicid verkan.

Teststyckena doppades i tjärprodukterna under 30 minuter och torkades i ett ventilerat rum med UV strålning i 20 dagar. De behandlade test-

styckena ställdes att stå på sin sågade yta på en spikmatta och de vändes upp och ned varje dag under torkningsperioden i syfte att garantera en jämn behandling. Efter torkning i ugn på 103ºC i 18h vägdes teststyckena. Därefter tryckimpregnerades de med ojoniserat vatten och fick stå i vattenflaskor i 14 dagar. Under denna period byttes vattnet i flaskorna 10 gånger. Teststyckena torkades därefter igen i ugnen och massaförlusterna till följd av urlakning beräknades. Efter detta placerades teststyckena i små slutna burkar som steriliserades med gammastrålning.

Testkärlen preparerades enligt standarden. En malt-agar-lösning ympades med tre testorganismer (*Coniophora puteana*, *Gloeophyllum trabeum* och *Poria placenta)* och lades i testkärlen. Organismerna drevs i 2 veckor och efter detta placerades teststyckena med sina respektive kontroller i testkärlen. Testet räckte ca 16 veckor. Sedan torkades teststyckena rena från mycel, vägdes och torkades i ugn (18 timmar i 103ºC) och vägdes på nytt. Fukthalten och förlusten av massa beräknades.

Ingen av tjärprodukterna gav resistans mot *Poria placenta* eller *Gloeophyllum trabeum* i enlighet med testkriterierna i standardtesterna EN113 och prEN839. Det står i testkriterierna att en korrigerad massförlust för teststycken borde ligga under 3 % och endast ett teststycke tillåts ha en massförlust högre än 3 % men lägre än 5 % och endast med ytlig nedbrytning. Å andra sidan kunde tre tjärprodukter godkännas som trädskyddsmedel i testet mot *Coniophora puteana* och även en produkt kom nära dessa kriterier. Den mest relevanta svamporganismen i testet var *Gloeophyllum trabeum* eftersom den oftast förekommer i de konstruktionsmaterial – på tak och ovanför markytan, där talltjära vanligen används. Skador som förorsakas av *Coniophora puteana* ("källarsvampen") förekommer i källare där det är mörkt och nära till markytan. På dessa ställen används tjära sällan och tjära rekommenderas inte heller för sådan användning.

Testet indikerade att ingen av tjärprodukterna fungerade som ett trädskyddsmedel för påstrykning för att hindra nedbrytning av trävirke ovanför markytan. Därför rekommenderar testrapportens författare, SP Sveriges Tekniska Forskningsinstitut att talltjära inte skulle listas som biocid i biociddirektivet 98/8/EC.

På ett möte för de ansvariga biocidmyndigheterna i EUs medlemsländer enades man om att tjära, när den används för att behandla trä, inte ska betraktas som ett verksamt ämne med biocid verkan eller som en biocidprodukt under biociddirektivet 98/8/EG.

Appendices

Appendix 1. Calculation of correction value (from specimens in non-inoculated vessels)

Specimen no.	Treatment product	Vessel No.	Product amount applied (g/m^2)	Product amount applied, mean	OD wt after EN84 leaching [g]	Moist wt after 16 w in non-inoc. Vessels	OD wt after 16 weeks [g]	MC after 16 weeks [%]	Mass Loss [%]	Correction value [%]
96	Control (untreated)	29	0,0		10,774	13,841	10,630	30,2	1,34	
97	Control (untreated)	29	0,0		9,254	11,830	9,045	30,8	2,26	1,80
98	Control (untreated)	29	0,0		8,255	10,243	7,860	30,3	(4,79)	Mould
99	Control (untreated)	30	0,0		9,221	11,539	8,662	33,2	(6,06)	Mould
100	Control (untreated)	30	0,0	0	8,803	11,376	8,533	33,3	(3,06)	Mould
20	Retorte 1	1	211,6		9,861	12,745	9,856	29,3	0,06	
21	Retorte 1	1	236,8		8,345	10,575	8,344	26,7	0,01	
22	Retorte 1	1	167,8		9,486	12,230	9,475	29,1	0,12	
23	Retorte 1	2	270,5		8,078	10,275	8,067	27,4	0,14	
24	Retorte 1	2	197,1	217	9,532	12,341	9,521	29,6	0,12	0,09
40	Retorte 2	7	204,8		10,676	13,574	10,628	27,7	0,45	
41	Retorte 2	7	260,0		10,704	13,507	10,648	26,8	0,52	
42	Retorte 2	7	278,9		8,919	11,138	8,877	25,5	0,48	
43	Retorte 2	8	192,0		9,695	12,279	9,658	27,1	0,39	
44	Retorte 2	8	292,4	246	8,917	11,043	8,862	24,6	0,61	0,49
56	Retorte 3	13	214,3		9,768	12,268	9,748	25,8	0,20	
57	Retorte 3	13	214,1		11,081	14,047	11,057	27,0	0,22	
58	Retorte 3	13	232,6		10,628	13,420	10,600	26,6	0,27	
59	Retorte 3	14	284,8		8,894	11,056	8,867	24,7	0,31	
60	Retorte 3	14	270,7	243	8,895	11,033	8,859	24,5	0,41	0,28
51	Retorte 4	11	159,4		10,350	13,217	10,317	28,1	0,32	
52	Retorte 4	11	159,8		8,288	10,453	8,258	26,6	0,37	
53	Retorte 4	11	126,5		8,924	11,473	8,906	28,8	0,20	
54	Retorte 4	12	141,1		9,663	12,380	9,631	28,5	0,34	
55	Retorte 4	12	208,6	159	8,661	10,979	8,626	27,3	0,40	0,33
35	Kiln 1	5	316,4		8,902	11,014	8,869	24,2	0,37	
36	Kiln 1	5	235,6		9,679	12,289	9,653	27,3	0,27	
37	Kiln 1	5	196,6		10,154	12,919	10,127	27,6	0,26	
38	Kiln 1	6	318,1		8,908	11,160	8,873	25,8	0,40	
39	Kiln 1	6	216,8	257	10,283	12,994	10,255	26,7	0,28	0,32
61	Kiln 2	15	207,8		9,195	12,574	9,104	38,1	0,99	
62	Kiln 2	15	192,4		10,043	13,828	9,963	38,8	0,79	
63	Kiln 2	15	319,2		9,103	11,620	8,988	29,3	1,27	
64	Kiln 2	16	234,7		10,434	13,131	10,411	26,1	0,22	
65	Kiln 2	16	245,9	240	11,213	14,226	11,181	27,2	0,28	0,71
66	Kiln 3	17	286,5		8,911	11,054	8,875	24,6	0,41	
67	Kiln 3	17	221,5		9,748	12,376	9,718	27,4	0,30	
68	Kiln 3	17	166,1		10,062	12,801	10,030	27,6	0,32	
69	Kiln 3	18	274,7		9,020	11,771	8,926	31,9	1,04	
70	Kiln 3	18	189,7	228	10,002	12,910	9,939	29,9	0,63	0,54
71	Kiln 4	19	210,5		9,429	11,992	9,405	27,5	0,25	
72	Kiln 4	19	181,1		9,950	12,688	9,927	27,8	0,24	
73	Kiln 4	19	265,7		8,975	11,294	8,953	26,1	0,24	
74	Kiln 4	20	203,4		9,824	12,388	9,800	26,4	0,25	
75	Kiln 4	20	207,2	214	11,009	14,010	10,981	27,6	0,26	0,25
30	Kiln 5	3	266,9		8,774	11,057	8,744	26,5	0,34	
31	Kiln 5	3	312,4		9,040	11,334	9,002	25,9	0,42	
32	Kiln 5	3	220,8		10,313	13,008	10,284	26,5	0,28	
33	Kiln 5	4	242,1		11,178	14,223	11,141	27,7	0,33	
34	Kiln 5	4	235,2	255	10,498	13,343	10,466	27,5	0,30	0,34
76	Kiln 6	21	189,7		10,342	13,104	10,316	27,0	0,25	
77	Kiln 6	21	235,4		8,481	10,546	8,461	24,6	0,23	
78	Kiln 6	21	188,8		9,305	11,814	9,289	27,2	0,18	
79	Kiln 6	22	246,9		8,754	11,011	8,722	26,2	0,36	
80	Kiln 6	22	202,7	213	11,037	14,043	11,006	27,6	0,29	0,26
81	Cu-Napht	23	86,9		9,717	12,548	9,667	29,8	0,51	
82	Cu-Napht	23	149,7		8,251	10,548	8,193	28,7	0,71	
83	Cu-Napht	23	99,6		9,275	12,000	9,232	30,0	0,47	
84	Cu-Napht	24	63,8		9,467	12,273	9,418	30,3	0,52	
85	Cu-Napht	24	104,4	101	8,062	10,397	8,018	29,7	0,54	0,55
91	Servalac	27	145,5		9,534	12,122	9,515	27,4	0,20	
92	Servalac	27	145,5		10,741	13,774	10,726	28,4	0,14	
93	Servalac	27	136,2		10,136	13,030	10,130	28,6	0,06	
94	Servalac	28	146,7		8,344	10,418	8,272	25,9	0,87	
95	Servalac	28	137,5	142	10,832	13,913	10,826	28,5	0,05	0,26
16	Ret. 4, Shingle	265	34,3	Servalac	8,574	11,078	8,545	29,6	0,34	
17	Ret. 4, Shingle	265	56,8	Servalac	10,489	13,300	10,443	27,4	0,44	
18	Ret. 4, Shingle	266	41,9	Servalac	8,992	11,506	8,964	28,4	0,31	
19	Ret. 4, Shingle	266	17,7	Servalac	11,544	14,778	11,510	28,4	0,30	0,35

Appendix 2a. *Coniophora puteana*, test results for individual specimens

Specimen no.	Treatment product	Oven-dry wt before coating [g]	OD wt after coating [g]	Retention, product [g]	Product amount applied (g/m²)	Product amount applied, mean	OD wt after EN84 leaching [g]	ML due to EN84 leaching [%]	Test vessel No.	Moist wt after test [g]	OD wt after test [g]	MC after test [%]	non-corr. Mass Loss [%]	Correction value [%]	Corrected Mass loss [%]	Mean corrected Mass loss [%]	Controls, corrected mass loss [%]	Controls, mean corr mass loss [%]
346	Retorte 1	8,879	9,986	1,107	233,1		9,225	7,6	31	9,841	5,455	80	40,87	0,09	40,78		36,91	
347	Retorte 1	8,158	9,328	1,170	246,3		8,521	8,7	32	10,836	5,663	91	33,54	0,09	33,45		36,70	
348	Retorte 1	8,828	9,891	1,063	223,8		9,162	7,4	33	9,303	5,442	71	40,60	0,09	40,51		31,74	
349	Retorte 1	8,821	10,100	1,279	269,3		9,253	8,4	34	11,124	7,194	55	22,26	0,09	22,17	(± 8,64)	29,64	
350	Retorte 1	8,337	9,353	1,016	213,9	237	8,683	7,2	35	8,539	4,889	75	43,69	0,09	43,61	**36,10**	60,82	39,16
361	Retorte 2	8,239	9,427	1,188	250,1		9,272	1,6	46	9,713	5,979	62	35,52	0,49	35,03		55,75	
362	Retorte 2	9,799	10,779	0,980	206,3		10,662	1,1	47	12,006	8,325	44	21,92	0,49	21,43		35,43	
363	Retorte 2	8,497	9,776	1,279	269,3		9,628	1,5	48	14,789	8,622	72	10,45	0,49	9,96		42,17	
364	Retorte 2	8,467	9,755	1,288	271,2		9,611	1,5	49	9,768	6,498	50	32,39	0,49	31,90	(± 10,28)	36,06	
365	Retorte 2	9,549	10,486	0,937	197,3	239	10,379	1,0	50	11,016	7,080	56	31,78	0,49	31,29	**25,92**	48,79	43,64
376	Retorte 3	8,416	9,613	1,197	252,0		9,480	1,4	61	13,081	8,315	57	12,29	0,28	12,01		25,61	
377	Retorte 3	9,442	10,634	1,192	250,9		10,505	1,2	62	14,311	8,898	61	15,30	0,28	15,02		42,53	
378	Retorte 3	8,093	9,155	1,062	223,6		9,058	1,1	63	13,615	8,660	57	4,39	0,28	4,11		44,88	
379	Retorte 3	9,302	10,331	1,029	216,6		10,218	1,1	64	13,208	7,984	65	21,87	0,28	21,59	(± 6,94)	59,84	
380	Retorte 3	8,525	9,541	1,016	213,9	231	9,444	1,0	65	13,048	8,799	48	6,83	0,28	6,55	**13,18**	49,53	44,48
371	Retorte 4	8,153	9,033	0,880	185,3		8,820	2,4	56	14,339	8,740	64	0,91	0,33	0,58		55,62	
372	Retorte 4	9,244	10,021	0,777	163,6		9,838	1,8	57	15,352	9,760	57	0,80	0,33	0,47		45,42	
373	Retorte 4	8,725	9,511	0,786	165,5		9,321	2,0	58	14,753	9,252	59	0,75	0,33	0,42		45,72	
374	Retorte 4	9,516	10,147	0,631	132,8		10,000	1,4	59	15,426	9,934	55	0,66	0,33	0,33	(± 0,16)	36,03	
375	Retorte 4	8,251	9,046	0,795	167,4	163	8,855	2,1	60	13,336	8,759	52	1,08	0,33	0,75	**0,51**	50,19	46,60
356	Kiln 1	8,781	10,134	1,353	284,8		9,892	2,4	41	14,835	8,489	75	14,18	0,32	13,87		44,98	
357	Kiln 1	9,259	10,361	1,102	232,0		10,172	1,8	42	12,307	8,498	45	16,45	0,32	16,14		47,49	
358	Kiln 1	8,721	9,899	1,178	248,0		9,687	2,1	43	16,028	9,587	67	1,03	0,32	0,72		50,33	
359	Kiln 1	8,086	9,333	1,247	262,5		9,157	1,9	44	13,075	8,894	47	2,88	0,32	2,56	(± 7,93)	34,15	
360	Kiln 1	9,308	10,432	1,124	236,6	253	10,240	1,8	45	12,335	8,406	47	17,91	0,32	17,59	**10,18**	46,33	44,66
381	Kiln 2	9,836	10,700	0,864	181,9		10,574	1,2	66	11,506	7,893	46	25,35	0,71	24,64		43,46	
382	Kiln 2	8,776	10,045	1,269	267,2		9,869	1,8	67	16,757	9,605	74	2,67	0,71	1,96		55,35	
383	Kiln 2	8,624	9,889	1,265	266,3		9,706	1,9	68	15,227	9,582	59	1,28	0,71	0,57		41,57	
384	Kiln 2	9,305	10,460	1,155	243,2		10,304	1,5	69	14,752	10,091	46	2,07	0,71	1,36	(± 10,46)	36,61	
385	Kiln 2	8,291	9,445	1,154	242,9	240	9,309	1,4	70	13,250	9,128	45	1,94	0,71	1,23	**5,95**	36,50	42,70
386	Kiln 3	8,093	9,152	1,059	222,9		9,017	1,5	71	14,246	8,934	59	0,92	0,54	0,38		52,20	
387	Kiln 3	8,858	10,309	1,451	305,5		10,153	1,5	72	14,482	9,578	51	5,67	0,54	5,13		50,84	
388	Kiln 3	8,293	9,260	0,967	203,6		9,134	1,4	73	14,336	8,989	59	1,58	0,54	1,04		48,82	
389	Kiln 3	9,189	9,846	0,657	138,3		9,686	1,6	74	14,342	8,980	60	7,29	0,54	6,75	(± 2,71)	51,60	
390	Kiln 3	8,153	9,463	1,310	275,8	229	9,275	2,0	75	14,214	8,846	61	4,62	0,54	4,08	**3,42**	49,02	50,50
391	Kiln 4	9,556	10,442	0,886	186,5		10,304	1,3	76	0,001	10,203	-100	0,98	0,25	0,73		39,41	
392	Kiln 4	8,386	9,330	0,944	198,7		9,197	1,4	77	13,475	8,951	51	2,68	0,25	2,43		46,41	
393	Kiln 4	8,176	9,394	1,218	256,4		9,207	2,0	78	15,020	9,077	65	1,42	0,25	1,17		48,75	
394	Kiln 4	8,888	10,000	1,112	234,1		9,817	1,8	79	15,458	9,568	62	2,54	0,25	2,29	(± 0,80)	53,54	
395	Kiln 4	8,912	10,045	1,133	238,5	223	9,864	1,8	80	16,082	9,749	65	1,17	0,25	0,92	**1,51**	51,41	47,90
351	Kiln 5	8,695	10,003	1,308	275,4		9,776	2,3	36	14,361	9,653	49	1,26	0,34	0,92		52,67	
352	Kiln 5	8,477	9,587	1,110	233,7		9,434	1,6	37	12,841	9,076	41	3,80	0,34	3,46		31,66	
353	Kiln 5	9,775	10,754	0,979	206,1		10,593	1,5	38	16,621	10,141	64	4,27	0,34	3,94		57,37	
354	Kiln 5	9,974	10,829	0,855	180,0		10,673	1,4	39	16,292	10,322	58	3,29	0,34	2,95	(± 1,31)	49,03	
355	Kiln 5	8,220	9,386	1,166	245,5	228	9,170	2,3	40	14,494	9,010	61	1,74	0,34	1,41	**2,54**	49,91	48,13
396	Kiln 6	8,844	9,780	0,936	197,1		9,594	1,9	81	16,023	9,392	71	2,11	0,26	1,85		40,40	
397	Kiln 6	9,855	10,566	0,711	149,7		10,417	1,4	82	17,350	10,223	70	1,86	0,26	1,60		50,63	
398	Kiln 6	8,145	9,215	1,070	225,3		9,011	2,2	83	15,865	8,922	78	0,99	0,26	0,73		58,62	
399	Kiln 6	9,331	10,221	0,890	187,4		10,048	1,7	84	17,199	9,854	75	1,93	0,26	1,67	(± 0,43)	51,33	
400	Kiln 6	9,548	10,307	0,759	159,8	184	10,168	1,3	85	16,036	9,997	60	1,69	0,26	1,42	**1,45**	52,46	50,69
401	Cu-Napht	8,223	8,684	0,461	97,1		8,552	1,5	91	11,157	8,498	31	0,63	0,55	0,08		35,50	
402	Cu-Napht	9,268	9,670	0,402	84,6		9,561	1,1	92	12,628	9,501	33	0,63	0,55	0,08		50,62	
403	Cu-Napht	8,513	8,920	0,407	85,7		8,825	1,1	93	11,637	8,762	33	0,71	0,55	0,17		37,89	
404	Cu-Napht	8,708	9,201	0,493	103,8		9,082	1,3	94	11,905	9,027	32	0,60	0,55	0,05	(± 0,04)	41,04	
405	Cu-Napht	8,228	8,768	0,540	113,7	97	8,651	1,3	95	11,966	8,594	39	0,66	0,55	0,11	**0,10**	39,23	40,85
411	Servalac	8,561	9,306	0,745	156,8		9,204	1,1	101	10,027	5,772	74	37,29	0,26	37,03		53,25	
412	Servalac	8,808	9,503	0,695	146,3		9,417	0,9	102	10,324	6,352	63	32,55	0,26	32,28		50,85	
413	Servalac	8,416	9,130	0,714	150,3		9,070	0,7	103	11,525	8,381	38	7,60	0,26	7,34		46,16	
414	Servalac	8,452	9,266	0,814	171,4		9,165	1,1	104	10,800	6,330	71	30,94	0,26	30,67	(± 11,67)	26,79	
415	Servalac	8,791	9,491	0,700	147,4	154	9,394	1,0	105	10,585	6,426	65	31,59	0,26	31,33	**32,83**	24,83	40,38
4	Ret 4, Shingle	10,256	10,528	0,272	57,3		10,399	1,2	86	13,140	9,180	43	11,72	0,35	11,38		18,31	
5	Ret 4, Shingle	12,157	12,405	0,248	52,2		12,257	1,2	87	14,591	9,472	54	22,72	0,35	22,37		25,77	
6	Ret 4, Shingle	9,749	10,008	0,259	54,5		9,913	0,9	88	11,432	6,942	65	29,97	0,35	29,63	(± 4,58)	36,46	
7	Ret 4, Shingle	11,793	12,034	0,241	50,7		11,888	1,2	89	13,073	8,180	60	31,19	0,35	30,84	**27,62**	31,63	31,29

Appendix 2b. *Gloeophyllum trabeum*, test results for individual specimens

Specimen no.	Treatment product	Oven-dry wt before coating [g]	OD wt after coating [g]	Retention, product [g]	Product amount applied (g/m²)	Product amount applied, mean	OD wt after EN84 leaching [g]	ML due to EN84 leaching [%]	Test vessel No.	Moist wt after test [g]	OD wt after test [g]	MC after test [%]	non-corr. Mass Loss [%]	Correction value [%]	Corrected Mass loss [%]	Mean corrected Mass loss [%]	Controls, corrected mass loss [%]	Controls, mean corr mass loss [%]
416	Retorte 1	8,871	9,953	1,082	227,8		9,212	7,4	109	9,770	6,457	51	29,91	0,09	29,82		28,70	
417	Retorte 1	8,256	9,402	1,146	241,3		8,614	8,4	110	9,896	5,922	67	31,25	0,09	31,16		26,84	
418	Retorte 1	8,346	9,350	1,004	211,4		8,674	7,2	111	9,833	6,013	64	30,68	0,09	30,59		21,05	
419	Retorte 1	9,022	10,026	1,004	211,4		9,350	6,7	112	11,113	6,778	64	27,51	0,09	27,42	(±1,43)	22,51	
420	Retorte 1	9,580	10,363	0,783	164,8	211	9,816	5,3	113	11,620	6,920	68	29,50	0,09	29,41	**29,68**	30,69	25,96
431	Retorte 2	9,644	10,532	0,888	186,9		10,426	1,0	124	11,428	7,171	59	31,22	0,49	30,73		31,40	
432	Retorte 2	9,062	9,988	0,926	194,9		9,874	1,1	125	10,796	6,765	60	31,48	0,49	30,99		29,19	
433	Retorte 2	8,216	9,463	1,247	262,5		9,314	1,6	126	9,472	6,097	55	34,54	0,49	34,05		37,28	
434	Retorte 2	9,028	10,053	1,025	215,8		9,942	1,1	127	10,735	6,737	59	32,24	0,49	31,75	(±2,12)	36,43	
435	Retorte 2	9,603	10,478	0,875	184,2	209	10,369	1,0	128	11,038	6,626	67	36,10	0,49	35,61	**32,63**	31,95	33,25
446	Retorte 3	9,183	10,180	0,997	209,9		10,062	1,2	139	10,699	7,115	50	29,29	0,28	29,01		27,49	
447	Retorte 3	8,116	9,352	1,236	260,2		9,250	1,1	140	10,227	7,097	44	23,28	0,28	23,00		32,31	
448	Retorte 3	8,846	9,942	1,096	230,7		9,824	1,2	141	10,324	6,790	52	30,89	0,28	30,60		24,08	
449	Retorte 3	9,061	10,137	1,076	226,5		10,012	1,2	142	10,996	7,342	50	26,67	0,28	26,39	(±2,91)	30,29	
450	Retorte 3	9,616	10,484	0,868	182,7	222	10,377	1,0	143	11,380	7,622	49	26,55	0,28	26,27	**27,05**	25,09	27,85
442	Retorte 4	8,841	9,628	0,787	165,7		9,434	2,0	135	15,482	9,113	70	3,40	0,33	3,07		49,76	
443	Retorte 4	8,997	9,751	0,754	158,7		9,570	1,9	136	14,730	9,134	61	4,55	0,33	4,23		46,94	
444	Retorte 4	9,970	10,536	0,566	119,2		10,394	1,3	137	15,658	9,412	66	9,44	0,33	9,12	(±2,76)	53,72	
445	Retorte 4	8,056	8,848	0,792	166,7	157	8,655	2,2	138	12,022	8,306	45	4,03	0,33	3,71	**5,03**	28,27	45,20
426	Kiln 1	8,545	9,864	1,319	277,7		9,632	2,4	119	15,052	9,081	66	5,72	0,32	5,40		44,52	
427	Kiln 1	8,960	10,253	1,293	272,2		10,021	2,3	120	14,894	9,550	56	4,71	0,32	4,39		40,47	
428	Kiln 1	8,522	9,535	1,013	213,3		9,386	1,6	121	13,258	8,926	49	4,91	0,32	4,59		37,17	
429	Kiln 1	9,134	10,228	1,094	230,3		10,047	1,8	122	14,930	9,244	62	7,99	0,32	7,68	(±1,30)	43,36	
430	Kiln 1	8,314	9,694	1,380	290,5	257	9,476	2,2	123	13,738	8,932	54	5,74	0,32	5,42	**5,50**	37,54	40,61
451	Kiln 2	9,109	10,063	0,954	200,8		9,910	1,5	144	12,559	8,480	48	14,43	0,71	13,72		52,46	
452	Kiln 2	8,094	9,346	1,252	263,6		9,155	2,0	145	15,161	8,682	75	5,17	0,71	4,46		44,41	
453	Kiln 2	9,284	10,404	1,120	235,8		10,241	1,6	146	15,229	9,636	58	5,91	0,71	5,20		46,88	
454	Kiln 2	9,055	10,181	1,126	237,1		10,001	1,8	147	11,458	8,281	38	17,20	0,71	16,49	(±5,45)	39,08	
455	Kiln 2	8,144	9,405	1,261	265,5	241	9,218	2,0	148	13,337	8,546	56	7,30	0,71	6,59	**9,29**	42,63	45,09
456	Kiln 3	8,140	9,242	1,102	232,0		9,059	2,0	149	13,911	8,586	62	5,22	0,54	4,68		40,68	
457	Kiln 3	8,979	9,974	0,995	209,5		9,808	1,7	150	11,063	7,630	45	22,20	0,54	21,66		41,74	
458	Kiln 3	9,530	10,359	0,829	174,5		10,227	1,3	151	12,394	8,560	45	16,30	0,54	15,76		38,98	
459	Kiln 3	8,952	10,031	1,079	227,2		9,868	1,6	152	16,637	9,445	76	4,29	0,54	3,75	(±7,60)	52,17	
460	Kiln 3	8,747	9,894	1,147	241,5	217	9,728	1,7	153	12,459	8,757	42	9,98	0,54	9,44	**11,06**	42,18	43,15
461	Kiln 4	8,924	10,011	1,087	228,8		9,834	1,8	154	11,876	7,980	49	18,85	0,25	18,60		39,37	
462	Kiln 4	9,724	10,559	0,835	175,8		10,424	1,3	155	16,119	9,933	62	4,71	0,25	4,46		48,67	
463	Kiln 4	9,379	10,381	1,002	210,9		10,228	1,5	156	16,348	9,792	67	4,26	0,25	4,02		53,63	
464	Kiln 4	8,027	9,159	1,132	238,3		9,006	1,7	157	14,592	8,756	67	2,77	0,25	2,52	(±6,90)	41,47	
465	Kiln 4	8,126	9,356	1,230	258,9	223	9,151	2,2	158	14,464	8,918	62	2,55	0,25	2,30	**6,38**	45,28	45,68
421	Kiln 5	8,235	9,557	1,322	278,3		9,340	2,3	114	14,527	9,050	61	3,11	0,34	2,77		44,16	
422	Kiln 5	8,402	9,691	1,289	271,4		9,465	2,3	115	11,969	8,601	39	9,13	0,34	8,79		34,20	
423	Kiln 5	9,880	10,748	0,868	182,7		10,592	1,5	116	13,206	10,019	32	5,41	0,34	5,08		27,71	
424	Kiln 5	8,614	9,920	1,306	274,9		9,709	2,1	117	14,722	9,157	61	5,69	0,34	5,35	(±2,19)	47,79	
425	Kiln 5	9,427	10,405	0,978	205,9	243	10,248	1,5	118	14,435	9,749	48	4,87	0,34	4,53	**5,31**	38,41	38,45
466	Kiln 6	9,712	10,410	0,698	146,9		10,255	1,5	159	11,018	7,442	48	27,44	0,26	27,17		33,14	
467	Kiln 6	8,115	9,202	1,087	228,8		8,994	2,3	160	14,152	8,360	69	7,05	0,26	6,79		44,78	
468	Kiln 6	9,405	10,250	0,845	177,9		10,079	1,7	161	11,600	7,585	53	24,75	0,26	24,48		42,50	
469	Kiln 6	8,152	9,220	1,068	224,8		9,063	1,7	162	15,172	9,014	68	0,54	0,26	0,27	(±9,04)	47,34	
470	Kiln 6	9,043	10,132	1,089	229,3	202	9,948	1,8	163	11,828	7,960	49	19,99	0,26	19,72	**15,69**	45,98	42,75
471	Cu-Napht	10,218	10,692	0,474	99,8		10,566	1,2	169	14,038	10,491	34	0,71	0,55	0,16		30,48	
472	Cu-Napht	9,079	9,583	0,504	106,1		9,463	1,3	170	12,741	9,400	36	0,67	0,55	0,12		31,22	
473	Cu-Napht	8,166	8,643	0,477	100,4		8,544	1,1	171	11,255	8,479	33	0,76	0,55	0,22		33,69	
474	Cu-Napht	8,108	8,636	0,528	111,2		8,540	1,1	172	11,223	8,470	33	0,83	0,55	0,28	(±0,084	36,55	
475	Cu-Napht	7,660	8,168	0,508	106,9	105	8,053	1,4	173	10,814	7,982	35	0,88	0,55	0,33	**0,22**	43,14	35,02
481	Servalac	8,882	9,596	0,714	150,3		9,483	1,2	179	10,254	6,765	52	28,66	0,26	28,39		41,55	
482	Servalac	9,151	9,873	0,722	152,0		9,750	1,2	180	10,813	7,158	51	26,58	0,26	26,32		28,10	
483	Servalac	8,152	8,894	0,742	156,2		8,788	1,2	181	10,209	6,850	49	22,05	0,26	21,78		33,15	
484	Servalac	7,803	8,554	0,751	158,1		8,437	1,4	182	9,085	6,103	49	27,66	0,26	27,40	(±2,67	31,43	
485	Servalac	10,206	10,768	0,562	118,3	147	10,630	1,3	183	12,136	8,043	51	24,34	0,26	24,07	**25,59**	23,94	31,63
8	Ret 4, Shingle	11,366	11,583	0,217	45,7		11,445	1,2	164	12,181	7,709	58	32,65	0,35	32,30		19,81	
9	Ret 4, Shingle	9,900	10,135	0,235	49,5		10,052	0,8	165	10,515	7,043	49	29,94	0,35	29,59		34,31	
10	Ret 4, Shingle	7,862	8,010	0,148	31,2		7,923	1,1	166	8,464	5,472	55	30,93	0,35	30,58	(±3,52)	30,62	
11	Ret 4, Shingle	7,313	7,432	0,119	25,1		7,320	1,5	167	7,507	4,549	65	37,86	0,35	37,51	**32,50**	33,92	32,95

Appendix 2c. *Poria placenta*, test results for individual specimens

Specimen no.	Treatment product	Oven-dry wt before coating [g]	OD wt after coating [g]	Retention, product [g]	Product amount applied (g/m^2)	Product amount applied, mean	OD wt after EN84 leaching [g]	ML due to EN 84 leaching [%]	Test vessel No.	Moist wt after test [g]	OD wt after test [g]	MC after test [%]	non-corr. Mass Loss [%]	Correction value [%]	Corrected Mass loss [%]	Mean corrected Mass loss [%]	Controls, corrected mass loss [%]	Controls, mean corr mass loss [%]
486	Retorte 1	9,042	9,985	0,943	198,5		9,329	6,569855	187	11,927	6,633	80	28,90	0,09	28,81		31,96	
487	Retorte 1	8,074	9,245	1,171	246,5		8,446	8,642509	188	11,040	6,020	83	28,73	0,09	28,64		43,34	
488	Retorte 1	8,834	9,834	1,000	210,5		9,149	6,965629	189	14,175	6,628	114	27,56	0,09	27,47		35,86	
489	Retorte 1	8,109	9,218	1,109	233,5		8,509	7,691473	190	9,961	6,193	61	27,22	0,09	27,13	(±1,12)	44,10	
490	Retorte 1	9,131	10,063	0,932	196,2	217	9,433	6,260558	191	13,835	6,962	99	26,19	0,09	26,10	**27,63**	44,11	39,88
501	Retorte 2	9,862	10,693	0,831	174,9		10,57	1,150285	202	16,462	8,055	104	23,79	0,49	23,31		38,94	
502	Retorte 2	9,760	10,810	1,050	221,1		10,667	1,322849	203	13,491	7,722	75	27,61	0,49	27,12		37,43	
503	Retorte 2	10,093	11,027	0,934	196,6		10,89	1,242405	204	13,260	7,523	76	30,92	0,49	30,43		47,59	
504	Retorte 2	8,755	9,458	0,703	148,0		9,367	0,962148	205	13,164	6,608	99	29,45	0,49	28,96	(±2,79)	50,55	
505	Retorte 2	10,258	11,129	0,871	183,4	185	11,032	0,871597	206	14,269	8,156	75	26,07	0,49	25,58	**27,08**	44,94	43,89
516	Retorte 3	7,590	8,648	1,058	222,7		8,535	1,30666	217	9,332	5,485	70	35,73	0,28	35,45		48,50	
517	Retorte 3	10,332	11,268	0,936	197,1		11,142	1,118211	218	17,447	8,816	98	20,88	0,28	20,60		35,10	
518	Retorte 3	8,714	9,616	0,902	189,9		9,526	0,93594	219	13,328	7,203	85	24,38	0,28	24,10		35,04	
519	Retorte 3	10,771	11,543	0,772	162,5		11,416	1,100234	220	16,414	8,643	90	24,29	0,28	24,01	(±5,84)	34,11	
520	Retorte 3	10,050	10,982	0,932	196,2	194	10,851	1,192861	221	13,831	7,603	82	29,93	0,28	29,65	**26,76**	39,26	38,40
511	Retorte 4	7,931	8,594	0,663	139,6		8,447	1,710496	212	10,143	6,451	57	23,63	0,33	23,30		53,28	
512	Retorte 4	8,786	9,349	0,563	118,5		9,208	1,508183	213	12,098	6,844	77	25,67	0,33	25,34		46,59	
513	Retorte 4	7,800	8,415	0,615	129,5		8,273	1,687463	214	9,873	6,306	57	23,78	0,33	23,45		56,33	
514	Retorte 4	8,902	9,674	0,772	162,5		9,511	1,684929	215	11,539	7,657	51	19,50	0,33	19,17	(±3,00)	51,36	
515	Retorte 4	10,141	10,808	0,667	140,4	138	10,614	1,794967	216	12,238	7,687	59	27,58	0,33	27,26	**23,71**	43,30	50,17
496	Kiln 1	7,931	9,226	1,295	272,6		9,02	2,23282	197	11,130	6,724	66	25,46	0,32	25,14		39,53	
497	Kiln 1	9,029	10,171	1,142	240,4		9,982	1,858224	198	11,639	7,181	62	28,06	0,32	27,74		46,75	
498	Kiln 1	8,640	9,467	0,827	174,1		9,297	1,795711	199	10,928	6,494	68	30,15	0,32	29,83		39,85	
499	Kiln 1	7,848	8,833	0,985	207,4		8,672	1,82271	200	11,354	6,021	89	30,57	0,32	30,25	(±2,31)	52,42	
500	Kiln 1	10,078	11,161	1,083	228,0	225	10,955	1,845713	201	12,550	7,555	66	31,04	0,32	30,72	**28,74**	40,45	43,80
521	Kiln 2	7,365	8,496	1,131	238,1		8,331	1,94209	222	9,422	5,904	60	29,14	0,71	28,43		44,39	
522	Kiln 2	7,949	8,981	1,032	217,3		8,851	1,4475	223	9,731	5,869	66	33,69	0,71	32,98		37,63	
523	Kiln 2	10,794	11,562	0,768	161,7		11,406	1,349248	224	16,373	8,722	88	23,53	0,71	22,82		37,66	
524	Kiln 2	10,071	11,061	0,990	208,4		10,89	1,545972	225	12,756	7,618	67	30,04	0,71	29,33	(±3,94)	42,17	
525	Kiln 2	7,401	8,539	1,138	239,6	213	8,382	1,838623	226	?	5,664	?	32,43	0,71	31,72	**29,06**	39,17	40,20
526	Kiln 3	10,107	10,994	0,887	186,7		10,844	1,364381	227	14,690	7,877	86	27,36	0,54	26,82		37,47	
527	Kiln 3	9,853	10,787	0,934	196,6		10,639	1,372022	228	15,010	7,864	91	26,08	0,54	25,54		43,38	
528	Kiln 3	8,727	9,562	0,835	175,8		9,446	1,213135	229	12,679	6,970	82	26,21	0,54	25,67		37,77	
529	Kiln 3	7,796	8,836	1,040	218,9		8,684	1,720235	230	?	6,008	?	30,82	0,54	30,27	(±3,09)	39,08	
530	Kiln 3	9,968	10,740	0,772	162,5	188	10,614	1,173184	231	12,863	7,108	81	33,03	0,54	32,49	**28,16**	34,68	38,48
531	Kiln 4	8,158	9,217	1,059	222,9		9,043	1,887816	232	10,129	6,098	66	32,56	0,25	32,32		41,40	
532	Kiln 4	9,289	10,155	0,866	182,3		10,005	1,477105	233	13,724	7,786	76	22,18	0,25	21,93		35,74	
533	Kiln 4	8,371	9,464	1,093	230,1		9,32	1,521555	234	11,183	7,084	58	23,99	0,25	23,75		45,90	
534	Kiln 4	9,808	10,829	1,021	214,9		10,65	1,652969	235	14,824	8,069	84	24,23	0,25	23,99	(±4,14)	36,98	
535	Kiln 4	9,766	10,739	0,973	204,8	211	10,567	1,601639	236	14,918	8,088	84	23,46	0,25	23,21	**25,04**	36,13	39,23
491	Kiln 5	10,229	11,024	0,795	167,4		10,87	1,396952	192	12,937	7,524	72	30,78	0,34	30,44		45,54	
492	Kiln 5	8,873	9,977	1,104	232,4		9,789	1,884334	193	11,257	6,929	62	29,22	0,34	28,88		45,72	
493	Kiln 5	9,020	9,986	0,966	203,4		9,812	1,742439	194	11,852	7,110	67	27,54	0,34	27,20		43,08	
494	Kiln 5	8,058	9,239	1,181	248,6		9,073	1,796731	195	10,515	6,812	54	24,92	0,34	24,59	(±2,31)	39,13	
495	Kiln 5	8,745	9,826	1,081	227,6	216	9,645	1,842052	196	11,531	6,766	70	29,85	0,34	29,51	**28,13**	37,50	42,19
536	Kiln 6	7,937	8,748	0,811	170,7		8,605	1,634659	237	10,325	6,094	69	29,19	0,26	28,92		43,04	
537	Kiln 6	7,651	8,547	0,896	188,6		8,385	1,895402	238	12,164	6,345	92	24,33	0,26	24,06		40,92	
538	Kiln 6	9,754	10,623	0,869	182,9		10,46	1,534406	239	14,368	7,656	88	26,81	0,26	26,55		39,56	
539	Kiln 6	10,173	11,153	0,980	206,3		10,954	1,784273	240	13,731	8,098	70	26,07	0,26	25,81	(±2,47)	35,07	
540	Kiln 6	10,351	11,059	0,708	149,1	180	10,913	1,320192	241	13,208	7,585	74	30,50	0,26	30,24	**27,12**	34,31	38,58
541	Cu-Napht	8,998	9,506	0,508	106,9		9,397	1,146644	247	16,888	8,929	89	4,98	0,55	4,44		51,32	
542	Cu-Napht	8,762	9,236	0,474	99,8		9,132	1,126029	248	12,384	7,752	60	15,11	0,55	14,56		55,58	
543	Cu-Napht	9,701	10,081	0,380	80,0		9,974	1,061403	249	14,245	9,143	56	8,33	0,55	7,78		49,66	
544	Cu-Napht	8,088	8,657	0,569	119,8		8,558	1,143583	250	14,874	8,513	75	0,53	0,55	-0,02	(±5,94)	52,83	
545	Cu-Napht	9,236	9,687	0,451	94,9	100	9,572	1,187158	251	12,661	8,312	52	13,16	0,55	12,61	**7,87**	53,99	52,68
551	Servalac	10,093	10,800	0,707	148,8		10,647	1,416667	257	11,301	6,060	86	43,09	0,26	42,82		38,46	
552	Servalac	8,875	9,755	0,880	185,3		9,645	1,127627	258	11,262	6,350	77	34,16	0,26	33,89		42,14	
553	Servalac	10,053	10,656	0,603	126,9		10,529	1,191817	259	11,950	6,539	83	37,90	0,26	37,63		38,94	
554	Servalac	9,871	10,484	0,613	129,1		10,36	1,182755	260	8,523	6,606	29	36,24	0,26	35,97	(±3,80)	43,28	
555	Servalac	7,717	8,476	0,759	159,8	150	8,375	1,1916	261	8,540	4,854	76	42,05	0,26	41,78	**38,42**	38,56	40,28
12	Ret 4, Shingle	9,218	9,365	0,147	30,9		9,23	1,441538	242	13,196	6,900	91	25,25	0,35	24,90		42,55	
13	Ret 4, Shingle	10,085	10,353	0,268	56,4		10,259	0,907949	243	16,434	8,272	99	19,37	0,35	19,02		37,74	
14	Ret 4, Shingle	6,586	6,732	0,146	30,7		6,641	1,351753	244	11,454	5,038	127	24,14	0,35	23,80	(±2,90)	40,08	
15	Ret 4, Shingle	9,727	9,843	0,116	24,4		9,754	0,904196	245	14,623	7,781	88	20,23	0,35	19,88	**21,90**	34,31	38,67

Appendix 3. Pictures of specimens after test

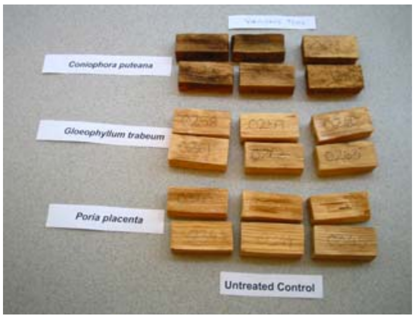

Figure 1. Virulence test

Figure 2. Retorte 4 coated roof shingle

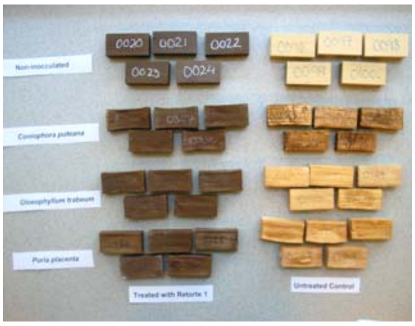

Figure 3. Retorte tar 1

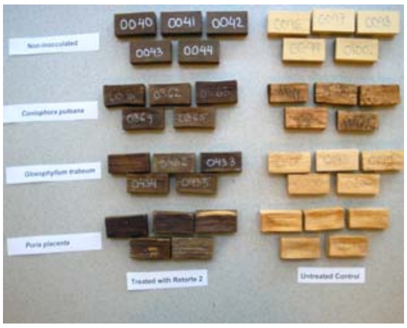

Figure 4. Retorte tar 2

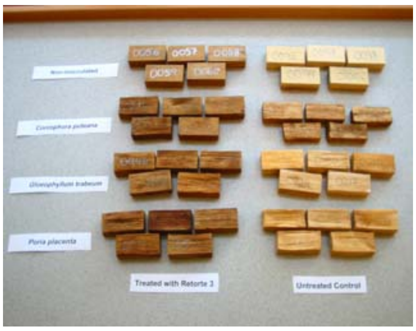

Figure 5. Retorte 3

Figure 6. Retorte 4

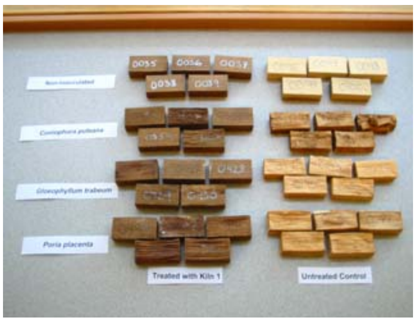

Figure 7. Kiln tar 1

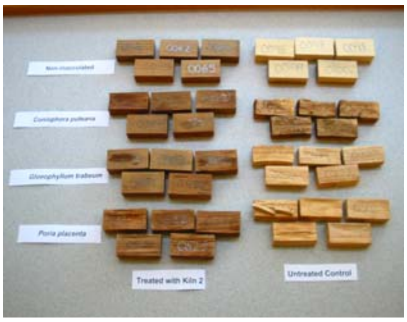

Figure 8. Kiln tar 2

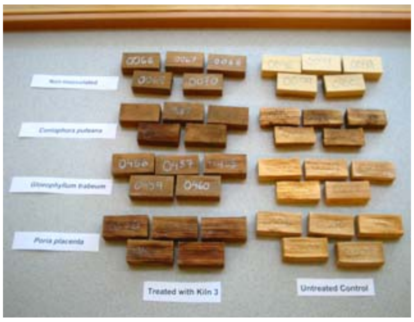

Figure 9. Kiln tar 3

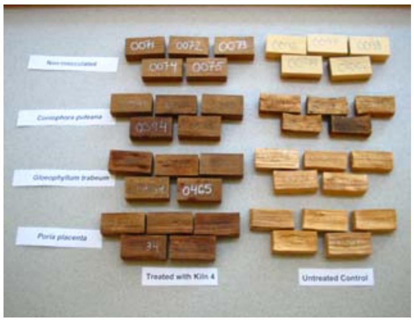

Figure 10. Kiln tar 4

Figure 11. Kiln tar 5

Figure 12. Kiln tar 6

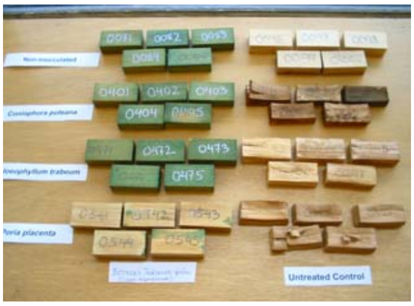

Figure 13. Reference preservative

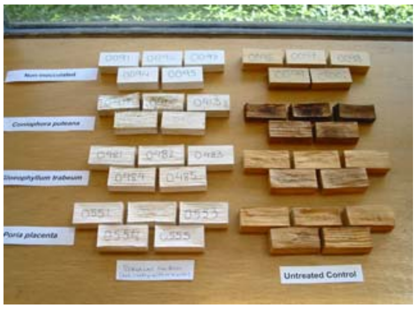

Figure 14. Reference non-fungicidal coating