International Biodeterioration & Biodegradation 90 (2014) 52–56

Contents lists available at ScienceDirect

International Biodeterioration & Biodegradation

journal homepage: www.elsevier.com/locate/ibiod

Investigations on natural durability of important European wood species against wood decay fungi. Part 1: Laboratory tests

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ARTICLE INFO

Article history:
Received 4 October 2013
Received in revised form
20 January 2014
Accepted 27 January 2014
Available online 7 March 2014

Keywords:
Natural durability
Basidiomycetes
Soft rot
Fungi
Heartwood

ABSTRACT

The durability of heartwood from European larch, Sessile oak and Scots pine was tested in laboratory against wood decay basidiomycetes and soft rot. The durability test was performed according to CEN/TS 15083-1:2005 with *Coniophora puteana*, *Oligoporus* (*Poria*) *placenta* and *Trametes* (*Coriolus*) *versicolor*. CEN/TS 15083-2:2005 was applied in order to test the timber with a bioactive soil substrate against soil rotting organisms. For Sessile oak, a very high durability against basidiomycetes (DC 1) was found in contrast to a low durability (DC 4) against soft rot fungi. Furthermore the results indicated that the durability of European larch and Scots pine is slightly deteriorated after leaching according to EN 84:1997. Beside this a minor influence of raw density on mass loss was detected for larch.

1. Introduction

The natural durability is an important property of wood regarding performance and service life. It is mainly affected by the resistance against wood decay fungi. EN 350-1:1994 defines requirements for the determination of natural durability against fungi, wood-boring beetles and termites and describes the classification of durability (DC). EN 350-2:1994 contains durability and preservative treatability specifications of selected wood species important in Europe. Corresponding fungal resistance data base on different sources such as practical experience, laboratory tests and in ground field tests. Most data originate from inconsistent investigations in the 1960s and 1970s which have been reviewed and evaluated by Bellmann in 1988. The actualisation and systematic enlargement of this database using standardised methods is a main part of ongoing standardisation activities of the European Committee for Standardisation (Technical Committee 38: Durability of wood and wood-based products) (Kutnik, 2013). Thereby influences of different wood origins and quality variations within a species shall be considered more comprehensively. Furthermore different DC shall be defined according to different exposure and conditions (above-ground or in-ground).

Actually, the durability classification values given in the current issue of EN 350-2:1994 are under discussion, especially in case of European larch (*Larix decidua* MILL.) and European oak (*Quercus robur* L. and *Quercus petraea* (MATT.) LIEBL.). Since they are economical important wood species in Europe, clear durability data are needed for their proper use.

Currently European larch (*L. decidua* MILL.) is arranged to DC 3 to 4, in consistence with results from lab tests (e.g. Bellmann, 1988; Viitanen et al., 1997; Augusta, 2007) and field tests (Rapp et. al 2002, 2006). However the durability of larch is distinctly influenced by heartwood formation and density (Koch et al., 2007; Rehbein and Koch, 2010). In practical experiences larch timber often shows a better life performance than predicted.

European oak includes the species Sessile oak (*Q.petraea* (MATT.) LIEBL.) and English oak (*Q. robur* L.), which are classified to DC 2 (durable) according to EN 350-2:1994. Nevertheless various authors determined durability classes between DC 1 and DC 3 for European oak using laboratory tests with basidiomycetes (e.g. Van Acker et al., 2003; Augusta, 2007; Humar et al., 2008). In this context it has to be taken into account that the durability classification according to EN 350 actually refers to use class 4 (UC 4) conditions. This use class describes wood exposure in soil contact. In this situation wood decay is not only caused by basidiomycete fungi but also by soft rot fungi and bacteria. Thus testing of

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http://dx.doi.org/10.1016/j.ibiod.2014.01.016
0964-8305/

basidiomycetes resistance does not consider the whole spectrum of wood attacking microorganisms in practice.

Contrary results regarding natural durability of European oak were found by conducting tests in terrestrial microcosms (Augusta, 2007). So English oak was only classified to DC 5 in contrast to DC 1 in case of the basidiomycete labtest. This outcome was confirmed by Meyer et al. (2014) in principle when common test fungi were used. Surprisingly much higher decay resulting in DC 4 and 5 was found using an isolate of *Hypholoma fasciculare*, a very frequently occurring fungus in the test field of Hamburg which is typically not used as a test fungus.

The durability of oak in EN 350-2:1994 seems to be generally overestimated under consideration of lab tests with soil as well as field tests in ground and above ground where DC 4 or 5 were allocated (Brischke et al., 2009). Furthermore, Brischke et al. (2012) proved the higher importance of the material-inherent resistance in comparison to the construction details.

Another important influence factor to the lab results is the exposure prior to the test. It is known that the amount and the composition of extractable substances represent an essential factor regarding durability (Haupt et al., 2003; Rehbein and Koch, 2010). Nevertheless Brischke et al. (2013) found only a little influence of a leaching procedure for several wood species.

2. Material and methods

In this paper results of lab tests are reported which are part of a research project on the genetic diversity and succession of wood decay fungi at different locations, timber species and exposition conditions (project was funded by the German Federal Ministry of Economy). The durability of the above mentioned wood species was determined in lab and field tests with and without ground contact to generate more information about significance of lab tests and influence of climate and soil conditions during the field tests as well as of important wood decay organisms. In this context for use class 3 a double layer test (Rapp and Augusta 2004) is running at the IHD in Dresden since spring 2010. At the same time an in-ground field test (use class 4) for determination of natural durability according to prEN 252:2012 was started at five European sites as a round robin test (Dresden and Hamburg/Germany, Poznan/Poland, Bordeaux/France, Udine/Italy). Data from these field tests including description of the diversity of decay fungi will be presented in a second part of this publication in 2014.

2.1. Wood species

Heartwood of the following wood species was tested: *L. decidua* MILL. (European larch), *Pinus sylvestris* L. (Scots pine) and *Q. petraea* (MATT.) LIEBL. (Sessile oak). In Europe, Sessile oak is generally sold as a mix with English oak (*Q. robur* L.), at which English oak is more frequently used. In these investigations more specific information for *Q. petraea* should be generated to improve the current poor documentation. References were sapwood of *P. sylvestris* L. (Scots pine) and *Fagus sylvatica* L. (European beech). Specifications of the tested wood assortments are shown in Table 1.

The density was determined at specimens with the dimension of 50 × 25 × 15 mm^3 according to DIN 52182:1976 after conditioning in a climate 20 ± 2 °C and 65 ± 5% relative humidity until constant mass was reached.

2.2. Durability tests against basidiomycetes

This investigation was performed according to CEN/TS 15083-1:2005 at the IHD Dresden. The following fungi were used:

Table 1
Specification of the wood.

Wood species	Specifications
European larch (heartwood)	■ Assortment 1: provenance from northern limestone alps, altitude between 1100 and 1300 m, 3 scantlings ■ Assortment 2: commercial assortment, alpine provenance without specific declaration, 2 boards ■ Raw density: 450–690 kg/m^3
(The two assortments were mixed for the laboratory tests.)	
Scots pine (heartwood)	■ Commercial assortment from Germany and Scandinavia without specific declaration ■ 6 Planks from 6 trees ■ Raw density: 500–720 kg/m^3
Sessile Oak	■ Iversheimer forest near Münstereifel (Germany, North Rhine-Westphalia) ■ Altitude about 290 m, hillside situation ■ 4 Planks from 4 trees ■ Raw density: 570–770 kg/m^3
European beech	■ Reference for hardwood ■ Laboratory stock
Scots pine sapwood	■ Reference for softwood ■ Laboratory stock

- *Coniophora puteana* (Schumacher ex Fries), Karsten, strain DSM 3085 for hardwood and softwood,
- *Trametes* (*Coriolus*) *versicolor* (Linnaeus) Quélet, strain CTB 863A for hardwood,
- *Oligoporus placenta* (Fr.) Gilb. & Ryvarden, strain FPRL 280 for softwood, synonyms: *Poria placenta* (Fries) Cooke sensu J.Eriksson, *Rhodonia placenta* (Fr.) Niemelä, K.H. Larsson & Schigl.

All fungi were cultivated on 5% malt agar. A set of specimens were pre-conditioned by leaching according to EN 84:1997.

The dimensions of the specimens corresponded to 50 × 25 × 15 mm^3. They were stored in a climate 20 ± 2 °C and 65 ± 5% relative humidity until constant mass was reached. For the calculation of the dry mass before the test, additional specimens and reference specimens were conditioned and oven-dried at 103 °C for 18 h. After steam sterilisation two specimens of the same wood species were put with plastics spacers onto the mycelium in a Kolle flask. 30 replicates were used with and without leaching per test fungus. The test lasts 16 weeks in climate of 22 ± 2 °C and 70 ± 5% relative humidity. At the end of the test, the mycelium was removed from the specimens, and the mass loss was determined after oven-drying.

2.3. Durability tests against soft rot fungi

According to CEN/TS 15083-2:2005 so called mini stakes of 100 × 10 × 5 mm^3 were prepared, leached according to EN 84:1997 and conditioned in a climate chamber at 20 ± 2 °C and 65 ± 5% relative humidity. Beside this additional specimens were oven-dried for the calculation of the dry mass and the references. The used test substrate consisted of seedling soil, natural compost and sand (maximal water holding capacity: about 55%, pH-value 5.6).

Table 2
Classification of the durability.

	Description	Median mass loss [%] (basidiomycetes)	*x*-value (soft rot fungi)
1	Very durable	≤5	≤0.15
2	Durable	>5 till ≤ 10	>0.15 up to ≤ 0.30
3	Moderately durable	>10 till ≤ 15	>0.30 up to ≤ 0.60
4	Less durable	>15 till ≤ 30	>0.60 up to ≤ 0.90
5	Non-durable	>30	>0.90