

Use of furfurylated wood for the production of high-performance windows made of European timbers (WinFur)

FINAL REPORT

Title of the research project Use of furfurylated wood for the production of high-performance windows made of European timbers

Coordinator of the project Susanne Bollmus

BASIC PROJECT DATA

Project period 01.10.2007- -31.03.2011

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URL of the project

FUNDING

Total budget in EUR 365 000 Euro

Public funding from WoodWisdom-Net Research Total funding granted in EUR by source:

Programme:

Germany

Federal Ministry of Education and Research (BMBF)/
Project Management Agency Jülich (PtJ) 168.000 EUR

Norway

The Research Council of Norway (RCN) 84.000 EUR

Sweden

Swedish Governmental Agency for Innovation
Systems (VINNOVA) approx. 40.000 EUR

Other funding (INDUSTRY PARTNERS etc)

Menck Fenster GmbH 12.000 EUR
Kebony ASA 21.000 EUR
Sweden [Tanums Fönster AB] approx. 40. 000 EUR

PROJECT TEAM (main participants)

Susanne Bollmus Dipl.-Holzw. Researcher	F.	[University of Göttingen]	Germany	Federal Ministry of Education and Research (BMBF)/ Project Management Agency Jülich (PTJ)
Andreas Treu, Dr. Researcher	M	NFLI Norwegian Forest and, Landscape Institute The Institute is owned by the Norwegian Ministry of Agriculture and Food	Norway	Norwegian Research Council
Per Brynildsen, M.Sc. R&D Director	M	Kebony ASA	Norway	Norwegian Research Council
Rolf Menck, Dipl.-Holzw.	M	Menck Fenster GmbH	Germany	Federal Ministry of

CEO
Education and
Research (BMBF)/
Project Management
Agency Jülich (PTJ)

Mats Westin, Dr. Researcher	M	SP Technical Research Institute of Sweden	Swedish	Vinnova
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Annica Pilgård, Dr. Researcher	F	SP Technical Research Institute of Sweden	Swedish	Vinnova
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Börje Gustavsson, MSc Researcher	M	SP Technical Research Institute of Sweden	Swedish	Vinnova
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Hans Thulin, Dr. Managing Director	M	Tanums Fönster AB	Swedish	Tanums Fönster AB
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Andreas Långström, BSc Purchase and R&D	M	Tanums Fönster AB	Swedish	Tanums Fönster AB
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DEGREES

Degrees earned or to be earned within this project.

2009	Diploma	M	Stephanie Oelmann, 1983 Diploma in 2009	Albert-Ludwig- Universität Freiburg	Dr. Dr. Gero Becker Dr. Siegfried Fink Dr. Andreas Treu
2010	PhD	F	Annica Pilgård, 1978 PhD in June 2010	Chalmers Univ.	Greg Morrison Chalmers Mats Westin, SP Gry Alfredsen, NFLI

ABSTRACT

The objective of the project is the industrial application of furfurylated wood in the window market. Because of promising results concerning the wood species European beech, Common ash, Radiata pine and Southern yellow pine it was decided to evaluate material from these species.

The material exhibits promising wood water related behaviour, coating tests showed the coatability with selected commercial products. Additionally, outside and artificial weathering tests are still running. The results reveal the dark material becoming visible through the film of some coatings, other coatings show better results. It is also possible to produce 3-layer profiles with common gluing systems like PVAC D4, EPI or PU-S. The resistance against wood destroying fungi increased in a way that the material is suitable for the window application.

A lot of different investigations were performed to test the furfurylated material and the results are satisfying. The last step in the project was the production of prototypes for different investigations. The window companies reported no differences between using furfurylated wood compared to untreated wood within the production of the windows. The tests of full scale window prototypes according to seven test standards, e.g. "repeated opening and closing" and "water tightness against driving rain", showed that all windows fulfilled the criteria for approval in all tests but one in which only one window fulfilled the criteria. However, the failure for some of the windows in this particular test had nothing to do with the use of furfurylated wood, but rather a non-proven construction. The overall conclusion is that use of furfurylated wood material would be suitable for the window production.

1.1 Introduction

1.1.1 Background

During the last decades the use of wooden window constructions in Germany and Scandinavia has been decreasing. Plastic and aluminium frames dominate the window market because of their low maintenance-requirements compared to wooden frames. However plastic and aluminium frames are non-sustainable materials with poor ecobalances; enough reasons to develop improved wooden window constructions. The technical requirements for wood used in the window industry are very high. Dimensional stability and durability against wood destroying fungi are important properties which European wood species fulfil to a limited extent only. Due to these strong requirements, the German and Scandinavian window industry has a strong economic interest to use modified European wood species for the production of high-performance windows.

1.1.2 Objectives

The objective of the project was the industrial application of furfurylated wood and its introduction to the window market. Furfurylation of timber results in strongly increased dimensional stability and bio-resistance, which are key factors to potentially increase the utilization of timber for frame constructions in Central Europe. Furthermore, the market position of wood windows in Scandinavia will be strengthened.

To achieve the main objective, the project was divided into three stages:

1. Fundamental material property research on wood species, which had not been used in the modification process of Kebony and thereby widen the existing knowledge of furfurylated wood properties.
2. Window components of different designs made of furfurylated wood were investigated.
3. Development and testing of window prototypes.

1.2 Results and discussion

- The results of the different experiments are important to proof the basic requirements for the use in modern window constructions.
- Because of promising results concerning the wood species European beech, Common ash, Radiata pine and Southern yellow pine it was decided to evaluate material from these species within the project.
- The furfurylated wood shows a satisfactory behavior in moist surroundings, which leads to good expectations for the coating and weathering tests
- During outside exposure and during lab tests, tested coatings and glueing systems showed satisfied results.
- The water uptake and the swelling of the furfurylated wood samples are reduced compared to untreated samples. This is an important material property when it comes to dimensional stable wood products.
- The high dimensional stability, reduced water uptake as well as good water vapor resistance indicate that the furfurylated wood has great potential for the production of wooden windows.
- The toxicity of leachate of furfurylated wood is low compared to CCA and ScanImp treated wood in ecotox tests.
- The gathered water samples showed low toxicity for two different leaching tests. The toxicity values correlated well to the amount of leached furfuryl alcohol for both leaching methods. Furfurylated SYP had in general the lowest amount of leached furfuryl alcohol and the lowest toxicity compared to all other furfurylated wood species.

- The durability test showed good durability properties (low mass loss) for furfurylated Southern yellow pine for all tested fungi.
- The window companies reported no differences between using furfurylated wood compared to untreated wood within the production of the windows.
- The tests of full scale window prototypes according to seven test standards, e.g. “repeated opening and closing” and “water tightness against driving rain”, showed that all windows fulfilled the criteria for approval in six of the tests. In the remaining test, “water tightness...”, only one window fulfilled the highest criteria, whereas the other windows had more or less problems with leakage. However, this had nothing to do with the use of furfurylated wood, but rather a new non-proven construction that could probably be adjusted so that the windows would fulfil the criteria.
- Southern yellow pine showed good results in all of the tests and has potential for the production of window frames according to the tests performed.

1.3 Conclusions

- All tested furfurylated material (European beech, Common ash, Radiata pine and Southern yellow pine) seems to be suitable for the window production after lab and field trails.
- The results indicate, that a application for VFF HO.06-4 will be approved presumably
- The production and standardised testing of full-scale window prototypes indicates that the use of furfurylated wood will not cause any problems with fulfilling the criteria for the Scandinavian P-mark and the German RAL certificate. The only problem that occurred during testing had nothing to do with the wood material, but can be blamed on new non-proven constructions.
- The overall conclusion is that use of furfurylated wood material would be suitable for the window application.
- For the evaluation of the long term performance, further tests with prototypes made from furfurylated wood are necessary.

1.4a Capabilities generated by the project

- The main objective of this project was the industrial application of furfurylated wood and its introduction to the window market.
- For the German window market, it is beneficial to achieve a confirmation from the “Association of window- and cladding producer” (Verband der Fenster- und Fassadenhersteller e.V, VFF), that the material is suitable for window production. For this confirmation, miscellaneous material and product tests are required. If this confirmation is given, the material will be listed in the so-called VFF data sheet HO-06.4.
- Within this project, the majority of required material tests were performed and Kebony ASA was able to apply in December 2010

- Beside this application, Kebony was able to convince several window producers in Germany to test the material within the commercial production.
- The Swedish window manufacturer Tanums Fönster AB, in collaboration with Kebony, have decided to produce new window prototypes from furfurylated wood and test them at SP in order to receive the P-mark so that they can start commercial production of these type of windows for the Scandinavian market.

1.4b Utilisation of results

The project has accomplished product development and product characterisation for modified wood window frame materials to be marketed in Germany and Scandinavia.

Properties that are investigated and documented include:

- Physical properties (vapour diffusion, shrinkage and swelling, hardness, density, capillary water uptake, fire class)
- Decay resistance against brown rot and white rot.
- Mechanical properties (Bending strength, E-module, compression strength, fastener holding strength)
- Gluing properties
- Application tests (production and testing of window prototypes).
- The test results are compiled in dossiers which are used as basis for registration under VFF regulations in Germany, and for Scandinavian approvals.
- The first application for listing the first product under VFF HO.06-4 in Germany was submitted in December 2010.

For Kebony ASA, an industrial partner in the project, the deliverables from the project are important elements in building market acceptance through objective testing and documentation of products.

1.5 Publications and communication

a) Scientific publications

1. Articles in international scientific journals with peer review

De Vetter L; Pilgård A, Treu A; Westin M, Van. Acker J (2009). Combined evaluation of durability and ecotoxicity: A case study on furfurylated wood. Wood material sciences and engineering 1-2: 30-36.

Pilgård A, Treu A, Westin M, Gosselink R J A, Van Zeeland A N T (2010). Toxic hazard and chemical analysis on leachates from furfurylated wood. Environmental Toxicology and Chemistry 29(9): 1918-1924.

2. Articles in international scientific compilation works and international scientific conference proceedings with peer review

Puttmann S, Krause A, Pilgård A, Treu A, Militz H (2009). Furfurylated wood for wooden window constructions. 4th European Conference on Wood modification. Conference proceedings. 569-576.

Treu A, Pilgård A, Puttmann S, Krause A, Westin M. (2009). Material properties of furfurylated wood for window production. International Research Group on Wood protection. IRG/WP 09-40480.

3. Articles in national scientific journals with peer review

4. Articles in national scientific compilation works and national scientific conference proceedings with peer review

5. Scientific theses

Oelmann S. (2009). Antifungal properties of furfurylated wood and ecotoxicity of leaching water. Albert-Ludwig-Universität Freiburg. Diploma Thesis.

Pilgård A. (2010). Fungal degradation patterns and toxicity of furfurylated wood. Dept of Civil and Environmental Engineering, Chalmers University of Technology, Göteborg, Sweden. PhD Thesis ISBN 978-91-7385-380-4.

6. Other scientific publications, such as articles in scientific non-refereed journals and publications in university and institute series

Time, B. Treu, A (2007). Trevinduer og trekvalitet. TRE & Profil 4: 42-43

a) Other dissemination

Internal seminar within the NorDan group in Sweden, i.e. Tanums Fönster and BorDörren

Held in December 2010 to discuss whether they should go on with research on use of furfurylated wood in the future.

Innovationstag Firma Menck Fenster GmbH

Held in February 2011 in Hamburg to present new technologies within the window market to architects, civil engineers and representatives of public construction authorities.

The technical information from the project will be used directly in marketing and information material from Kebony ASA – not only for products to the joinery industry – but also for other

applications where good technical data is required. These applications could be decking, cladding, various indoor products.

1.6 National and international cooperation

- The number of participants in this WinFur project can be described as ideal.
- The cooperation of three research institutes and three industry partners was fruitful and productive over the period of three years.
- The Swedish industry partner did not show sufficient interest in the project, during most of the project period, which resulted in absence of a responsible contact person in nearly all project meetings. Hence, some working tasks were late. However, since they have now established a fruitful cooperation with the Norwegian industry, they have decided to continue this cooperation within other projects.
- The involvement of the German and Norwegian industry side was beneficiary
- The transnational cooperation is helping the Norwegian producer of furfurylated wood to open market shares in Germany and Sweden