COST MC Chair:
Prof. Dr. Stefanie Wieland
Salzburg University of Applied Sciences

STSM SCIENTIFIC REPORT

Action: COST FP1006
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COST STSM Reference Number: COST-STSM-ECOST-STSM-FP1006-010213-027357
STSM Research Theme: "Enhancing the bondability of wood veneers through surface activation treatment"
STSM Applicant: Dr. Pavlo Bekhta, National University of Forestry & Wood Technology of Ukraine, Department of Wood-Based Composites
Host: Assoc. Prof. Jan Sedliacik, Technical University in Zvolen, Department of Furniture and Wood Products

STSM Scientific Report Contents:

1. Purpose of the STSM

The quality of preparation of the wood surface prior adhesive or paint (lacquer) application is extremely important. Mechanical pre-treatments (such as sanding, planning or densification by rolling or pre-pressing) can be applied to modify the surface characteristics that improve adhesive bonding of wood. In order to improve bonding ability, wettability and to reactivate wood surfaces for glue-wood bonds, some chemical pre-treatments are widely applied to wood surfaces.

In accordance with this pre-treatment, the functional groups present on the wood surface are modified so that they can react and bond with the functional groups more effectively in the adhesive. Hereby, the surface of wood should be cleaned just before bonding in order to remove all foreign substances that interfere with bonding. Chemical method of surface treatment, when compared to the mechanical, is more efficient and affordable. Besides the fact that it has a cleansing effect, this treatment often provides creation of the chemical layer on the surface that promotes the long-term preservation of the bond strength.
The purpose of this STSM to Technical University in Zvolen was to study the combined effect of chemical and/or thermo-mechanical pre-treatment of veneer surface prior adhesive application on the bondability of wood veneers.

2. Description of the work carried out during the STSM

2.1. Materials

Rotary cut veneer sheets of birch (*Betula verrucosa Ehrh*.) with dimensions of 300 mm by 300 mm by 1.55-1.60 mm with moisture content of 5.7% were chosen for the experiments. Veneer sheets without visible defects were selected. Before chemical and/or thermo-mechanical densification, all test specimens were equilibrated at relative humidity of 65% and temperature of 20^{o}C.

2.2. Thermo-mechanical densification technique

Each veneer specimen was thermo-mechanically densified between the smooth and carefully cleaned heated plates of a laboratory press (Fig.1) at pressure of 2 MPa and at temperature of 150^{o}C.

Fig. 1. Laboratory press “FONTIJNE”

2.3. Chemical pre-treatment of veneer surface

Hydrogen peroxide (H_2O_2), aluminium potassium sulfate ($KAl(SO_4)_2$), potassium carbonate (K_2CO_3), and potassium permanganate ($KMnO_4$) with 6% concentration solution (each of them) were examined for veneer surface activation treatments. Surface activation was accomplished by spraying the activating agent on the veneer surfaces before adhesive application.

2.4. Manufacturing of plywood panel samples

In addition, three-layer experimental plywood panels were manufactured from veneers with treated and non-treated surfaces using commercial phenol-formaldehyde glue resin FENOKOL 43EX (producer Chemko, a.s Strazske, Slovakia, solid content was 47%, Ford cup (4 mm, 20°C) viscosity was 64 s) at following pressing factors: pressure of 1,8 MPa and temperature of 150^0C. The glue spread was 100 or 150 g/m^2 based on the wet mass. Description of the manufactured panels is shown in Table 1. For each treatment, the shear strength of plywood panels was measured using testing machine “LABOR TECH 4.050 9” (Fig.2) according to EN 314-1.

Fig. 2. Testing machine “LABOR TECH 4.050 9”

Table 1. Description of the manufacturing of plywood panels

Type of panel	Description of veneer surface pre-treatment and glue spread
A	Conventional veneer (Non-densified and without chemical pre-treatment) – control; glue spread 150 g/m^2
B	Thermo-mechanically densified veneer; glue spread 150 g/m^2
	Chemically treated veneer; glue spread 150 g/m^2:
C1	veneer surface treated by H_2O_2
C2	veneer surface treated by $KAl(SO_4)_2$
C3	veneer surface treated by K_2CO_3
C4	veneer surface treated by $KMnO_4$
	At first veneer was thermo-mechanically densified and then it was chemically treated; glue spread 100 g/m^2:
D1	veneer surface treated by H_2O_2
D2	veneer surface treated by $KAl(SO_4)_2$
D3	veneer surface treated by K_2CO_3
D4	veneer surface treated by $KMnO_4$
	At first veneer was chemically treated and then it was thermo-mechanically densified; glue spread 100 g/m^2:
E1	veneer surface treated by H_2O_2
E2	veneer surface treated by $KAl(SO_4)_2$
E3	veneer surface treated by K_2CO_3
E4	veneer surface treated by $KMnO_4$

3. Description of the main results obtained

The results revealed that the combined chemical and thermo-mechanical pre-treatment of veneer surface prior adhesive application improved the bondability of veneer even at lowering glue spread (a 33% reduction), as evidenced by higher values of shear strength of plywood compared to the non-treated surface or chemically treated surface (Table 2). Chemical pre-treatment of veneer surface before adhesive application results to a reduction in shear strength. This can be explained by increased moisture content of treated veneer and thus increased the probability of adhesive bonds failure under the effect of the excess pressure of gas-vapor mixture during pressing.

Table 2. Shear strength of plywood panels

Type of panel	Shear strength [MPa]
A	2,22
B	2,73
C1	1,26
C2	1,20
C3	1,44
C4	1,71
D1	1,55
D2	1,46
D3	1,00
D4	1,97
E1	2,05
E2	1,98
E3	1,86
E4	1,91

Based on the findings of this work such combined chemical and thermo-mechanical pre-treatment process could have potential to be used as alternative method to enhance properties of the plywood panels. Further studies are needed to examine the chemical changes on veneer surface after combined chemical and/or thermo-mechanical pre-treatment of surface.

4. Future collaboration with host institution (if applicable)

The STSM allowed me to exchange literature, knowledge, and research experiences. Directions for future collaboration were discussed during the visit and as the final result, some activities were decided on: (a) collaboration through publications: on international journals or through joint participations in international workshops; (b) collaboration through research projects; (c) collaboration through specific STSM actions to be investigated further.

5. Foreseen publications/articles to result from the STSM (if applicable)

The described work will hopefully lead to joint publications as agreed with Assoc. Prof. Jan Sedliacik, PhD. The results obtained during this mission will be presented in the future meetings within COST Action FP1006 and will be the issue for 1-2

articles in scientific journals. The results of this mission are stimulating new investigations on the application of the densification process for enhancing surface properties of veneer, which could be the issue of future collaboration between Technical University in Zvolen, Slovakia and National University of Forestry & Wood Technology of Ukraine.

6. Confirmation by the host institution of the successful execution of the STSM

The confirmation is in a separate file.

7. Other comments (if any)

As a matter of conclusion, this one month spent at the Technical University in Zvolen provided a very good opportunity for discussions with various people coming from various backgrounds and horizons.
I would like to thank the COST network for funding this visit. I would also like to thank my hosts, Assoc. Prof. Jan Sedliacik for inviting me to the Technical University in Zvolen. I would like to thank him for offering me an office space for the duration of my visit as well as for their providing me with such a welcoming and warm atmosphere. I am looking forward to continuing our collaborations very much.

March 30, 2013, Lviv, Ukraine

Prof. Ing. Pavlo Bekhta, DrSc.