



REPORT

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Report on the Troëdsson Adjunct Professorship in Forest-based Surface Chemistry at KTH financed by the Troëdsson Foundation – reporting period 2013-2014

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Preface

This report summarizes activities within a project funded by the Nils and Dorthi Troëdsson Foundation for Scientific Research (grant 738/10 and 852/14) at KTH and SP during 2013 and 2014. The project consists of the Troëdsson PhD project on sustainable wood modification by Maziar Sedighi and the Troëdsson Professorship in Forest-based Surface Chemistry by Adjunct Professor Agne Swerin. This report also summarizes recent activities thanks to earlier Troëdsson grants (638/06 and 764/11) for the combined Raman/AFM/SNOM instrumentation.

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1. Summary

The aim of the professorship is to strengthen the research area of surface science related to aspects vital for the forest-based sector. These are wetting, spreading and liquid imbibition in porous media, adhesion mechanisms and effect of local chemical and structural heterogeneities, interactions between non-polar surfaces and new analytical means based on world-class equipment for combinations of spectroscopy and microscopy.

Highlights of the activities within the Troëdsson professorship during the reporting period Dec. 2012-Nov. 2014 are:

- The Troëdsson PhD project of Maziar Sedighi has a planned doctoral defence autumn of 2015. Maziar received funding from the EU trees4future program for a research visit at the x-ray tomography facilities at Ghent University, Belgium. Maziar will from January 2015 spend half of his time within the new laboratory EnWoBio at KTH Building materials headed by Prof. Magnus Wålinder
- The PhD project of Lina Ejenstam (née Martinsson) has a planned doctoral defence during 2015. Lina is currently on parental leave and will return in Jan 2015. Her project is funded by Swedish Strategic Foundation (SSF) in the program “Microstructure, friction and corrosion control” and uses superhydrophobicity to achieve corrosion protection. The Troëdsson professorship supports the supervision.
- The postdoc project of Dr. Mikko Tuominen with funding from Troëdsson Foundation, two years 2012-2014 on 50 % of Mikko’s time. See separate report.
- The postdoc project of Dr. Petra Hansson together with Omya Development AG, Switzerland in 2013 on new uses of functional calcium carbonates. Petra is now project manager at SP Chemistry, Materials and Surfaces
- The postdoc project of Dr. Petru Niga together with Omya Development AG, Switzerland in 2013 on surface spectroscopic understanding of functional calcium carbonates.
- The PhD thesis and doctoral defence by Asaf Oko on inkjet printing, October 24, 2014
- The postdoc project of Asaf Oko together with KTH Mechanics (KTH postdoc Jordan MacKenzie) on rheology of fibrous suspensions
- The continuation of the Troëdsson professorship at KTH for Agne Swerin, 2014-16 with additional Troëdsson funding of 750 000 SEK for three years

- Completion of one publication on inkjet-printed sensors on paperboard for charged macromolecules and one fundamental study on mechanisms for superhydrophobicity
- 16 peer-reviewed publications, 14 conference proceedings and presentations and 1 patent application. 7 more publications are in preparation.

The Troëdsson Foundation is wholly or partly funding these activities and is acknowledged in publications and at presentations.

Recent funding from the Troëdsson foundation was allocated for the Troëdsson instrumentation for combined AFM/Raman/SNOM. Dr. Birgit D Brandner is the application specialist on these techniques with focus on confocal Raman microspectroscopy and is now planning for an associate professorship (docent) at KTH Surface and Corrosion Science in the area of applied spectroscopy.

2. Adjunct professorship in forest-based surface chemistry

The professorship started in January 2011 and contains:

- Description of current collaborations and research groups involved
- Plan for increased collaboration
- New PhD project
- Increased collaboration KTH-YKI together with other academic sites and research institutes
- Equipment upgrade of the Troëdsson instrument for confocal Raman/AFM/SNOM

2.1. Employment profile decided by KTH

The research area comprises forestry-based surface chemistry with a focus on dynamic processes such as flotation, cleaning, flocculation, dewatering, surface modification and printing as well as methodology for advanced surface analyses using spectroscopy and microscopy.

Persons eligible for employment has to have proven scientific and pedagogical excellence within the particular research area.

The applicant should have practical experience of industrial processes of paper production. An understanding of these process steps require good knowledge in polymer and surfactant adsorption, solubilization and micelle formation, rheological properties in shear and extensional flow, chemical formulation in multiphase complex systems, adhesion and effect of weak boundary layers, wetting, spreading and liquid penetration into porous media.

The applicant should also have a good ability to attract financing for advanced and focussed research aimed at applications and to initiate and lead research, not the least in form of PhD student supervision.

2.2. Research profile – professorship and PhD project

The research profile is on wetting, spreading, adhesion and liquid imbibition related to porous materials with local chemical and structural heterogeneities. This is of utmost importance to printing paper, food packaging, hygiene products and wood. The professorship will strive to match Troëdsson funding with industry, forest-based sector organizations and public funding through VINNOVA etc. and also strive for projects close to industrial needs, e.g. through an advisory group with industrial companies and continued financing after the first three-year period.

2.3. Teaching/tutoring profile

The background of Agne Swerin in teaching/tutoring is industrial courses (Innventia, Skogsindustrins Utbildningscenter, Markaryd, etc.), YKI Academy courses and KTH PhD courses. AS have supervised more than 10 MSc thesis supervision (two have received Bo Rydin prize for best thesis) and co-supervision in tekn.lic, PhD thesis (currently two) and postdoc projects (currently three). The aim is to increase the network, e.g. industrially in sustainable wood impregnation/engineered wood area (SP Trä, Innventia) and academically towards surface modification, wetting, spreading and adhesion between SP and KTH. Interesting applications exist in textiles (Textilhögskolan, Borås) and increased collaboration with Åbo Akademi and Aalto University is foreseen.

The aim is to contribute to PhD courses, given every other year and to increase contribution to existing courses, e.g. in FPIRC network and arranged by KTH Surface and Corrosion Science.

Include suitable courses to complement pedagogic area, e.g. "Research Supervision LH207V" or "Teaching and Learning in Higher Education LH201V".

3. PhD project: Enhancing wood protection by optimization the wettability and permeability

Maziar Sedighi Moghaddam was employed at YKI as a Troëdsson PhD student in May 2011. His main supervisor is Agne Swerin, and co-supervisors are Prof. Per Claesson at KTH Surface and Corrosion Science and Prof. Magnus Wålinder, now at KTH Building Materials (on leave from SP Trä). Maziar's background is:

- BSc in polymer engineering, 2003, Tehran Polytechnic
- Bachelor thesis title "Evaluating the effects of processing parameters on the residual stresses in injection molded PA6 and PA6/SGF"
- MSc in polymer engineering, 2006, Tehran Polytechnic
- Master thesis title "Kinetic study of HDPE polymerization using Ziegler-Natta catalyst, Evaluation of effective parameters on physical & molecular properties"
- Head of technical support and member of R&D in a Petrochemical company (Jam Polypropylene Co.), 2006-2010, Tehran

Maziar's PhD project complete study plan is attached as appendix and can be summarized under the title "wettability, sorption and permeability on wood with emphasis on modified wood". The objectives are:

- 1- Developing new methods for wettability study of wood samples by using Wilhelmy plate method and sessile drop method (Paper 1 and 2)
- 2- Applying these methods to study dynamic wettability of different wood samples (modified and unmodified) (Paper 2 and 3)
- 3- Correlating the wetting properties to surface chemical composition (studying by XPS imaging) and microstructure (studying by X-Ray tomography) with emphasis on pine sapwood/heartwood interface (Paper4)
- 4- Combining LFS (liquid flame spray) method and polymer plasma coating to create superhydrophobic surfaces of wood, wetting (paper5) and freezing (paper6) measurements
- 5- Micro structure study of modified wood by X-Ray tomography (paper7)

Maziar is using several experimental techniques, such as in wettability and permeability methods (Wilhelmy plate and sessile drop), in microscopy (SEM, AFM, X-ray tomography techniques) and in spectroscopy (XPS, IR and Confocal Raman microspectroscopy).

New approaches have been successfully developed for wettability study of swellable surfaces (e.g. wood) by using Wilhelmy plate method. The first two papers have been written based on these results. He has submitted paper 3 about applying these new techniques on modified wood. XPS analysis has been done based on the interface of wood sapwood and heartwood samples. (paper4) The superhydrophobic wood surfaces have been made using liquid flame spray technique and plasma coating. (paper 5&6).

Maziar's grant application to Trees4Future program has been accepted to do X-Ray tomography measurements on wood samples at Ghent University (Belgium) as an internship program. Trees4Future (www.trees4future.eu) is an Integrative European Research Infrastructure project that aims to integrate, develop and improve major forest genetics and forestry research infrastructures. Through their "Transnational Accesses" program, they support researchers by facilitating access to state-of-the-art research facilities throughout Europe. They cover all the instrumentation costs and major part of travel and subsistence costs. From Sweden, Innventia is involved in this program as a host institute by offering access to the SilviScan instrument. Another researcher from SLU (Sveriges Lantbruksuniversitet) did a research visit in Finland by using this program. Maziar was at Ghent University from 26 March to 20 April 2014 to investigate microstructure properties of modified wood samples (paper7) and pine sapwood/heartwood interface samples (paper4) by using X-Ray tomography technique. Maziar has finished 53 credits out of 60 of his PhD courses.

Published papers

Paper 1: "Comparison of different methods for studying wood wettability and liquid penetration" Wood Science and Technology 48(1)161-176.

Paper 2: "Multicycle Wilhelmy Plate Method for Wetting Properties, Swelling and Liquid Sorption of Wood" Langmuir 29 (39):12145-12153.

Submitted:

Paper 3: “Wettability and swelling of acetylated and furfurylated wood analyzed by multicycle Wilhelmy plate method” submitted 140703, revised 141110.

Publications in preparation:

Paper 4: “Supercooled water wettability on modified wood surfaces”

This manuscript is a collaboration with another PhD student at KTH (Golrokh Heydari) and is ready for submittal. Maziar has experimental and writing contribution in this work.

Paper 5: “Wood Surface Modification by Combining Plasma Coating and Liquid Flame Spray Methods: Wetting Properties and characterization”

Main experimental part of this paper has been done and Maziar has started to write the manuscript.

Conferences

- 1- Oral presentation at Northern European Network for Wood Science and Engineering (WSE) September 13 - 14, 2012, in Kaunas, Lithuania with title of “New approaches for studying wood wettability and liquid penetration by using Wilhelmy plate method”
- 2- Comparison of different methods for studying wood wettability and liquid penetration, Accepted as an oral presentation at 8th International Symposium on Contact Angle, Wettability and Adhesion. (Not presented due to late issued visa for Maziar Sedighi), Université Laval, Québec City, Québec, CANADA June 13-15, 2012
- 3- Oral presentation at Northern European Network for Wood Science and Engineering (WSE), September 10 - 11, 2013, in Hannover, Germany with title of “Development of a multi-cycle Wilhelmy plate method for studying dynamic wettability and swelling behavior of wood”
- 4- Oral presentation at the 7th European conference on wood modification (ECWM7), 10-12 Mar., 2014, in Lisbon, Portugal with title of “Wettability and swelling of acetylated and furfurylated wood analyzed by multicycle Wilhelmy plate method”
- 5- Oral presentation (presented by Agne Swerin) at ACS 2014 colloid and surface science symposium with title of “Novel single and multi-cycle Wilhelmy plate methods for wetting, swelling and sorption of porous materials such as wood”
- 6- Submitted an abstract in MRS 2015 (Material Research Society spring meeting) with title of “Wood Surface Modification by Combining Plasma Coating and Liquid Flame Spray Methods: Temperature-Wetting Properties”

4. Activities of Troëdsson professorship outside PhD project of Maziar Sedighi

There has been a focus in developing projects and collaborations in the research area related to the Forest Products sector. The Troëdsson instrument for confocal Raman/AFM/SNOM gives combined chemical, topographical and optical mapping at nanometer resolution and is a key instrument in the following on-going projects:

During 2013 and 2014 the adjunct professorship also includes supervision of two other PhD projects (Asaf Oko and Lina Martinsson). All of these are advancing according to plans and Asaf's defence was October 24, 2014.

Recent funding from the Troëdsson foundation was allocated for the Troëdsson instrumentation for combined AFM/Raman/SNOM. Dr. Birgit D Brandner is application specialist on these techniques with focus on confocal Raman microspectroscopy. Its use in fundamental research has continued and resulted in seven peer-reviewed publications in the two recent years. Birgit has performed fruitful collaboration with Malmö University (Raman on skin) and Karolinska Institute (Raman in cell tissue). Birgit is now planning for an associate professorship (docent) at KTH Surface and Corrosion Science. The subject is not yet decided but it will be in the area of applied spectroscopy.

The adjunct professorship and PhD project on wood modification has so far resulted in 30 publications and conference lectures. Seven manuscript are under preparation.

Sustainable wood impregnation (project ended 2011)

The aim was to investigate the concept of sustainable pressure impregnated wood in order to find out how to launch research and industry-linked projects. The concept will be based on combination of biorefinery material streams approaches with the impregnation process. Innventia will bring the biorefinery expertise, YKI the surface chemistry on wetting/spreading and liquid penetration and SP Träteknik the expertise on wood. The three institutes all have industrial and external R&D contacts to support the activities and planning for continued activities in the area.

This pre-project linked to the PhD project financed by Troëdsson foundation was started in autumn 2010 and finalized in autumn 2011 together with SP Trä and Innventia. The funding (total 1,2 MSEK, 400 kSEK to YKI) came from RISE Holding AB. One outcome was a VINNOVA project proposal together with five industrial companies.

Adhesion and friction in lignocellulosic fiber-fiber joints (ended 2010)

The project received funding for two years from Bo Rydin Foundation for Scientific Research and will run until spring 2010 and has additional industrial funding. The project combines AFM colloidal probe measurements for interaction forces and chemical mapping of bonding areas in the fiber-fiber joints. The project has a total budget of 1,8 MSEK.

NextJet – Next Generation Paper Substrates for Inkjet Printing

This project started 2007 and will run until 2012 and belongs to the Forest-based Industry Sectoral Programme at VINNOVA (Branschforskningsprogrammet för trä-, möbel- och skogsindustri). It has VINNOVA and Kempe Foundation funding and industrial funding and participation from Eka Chemicals, Metsä Board (formerly M-real), MoRe Research, Kodak and XaarJet. It involves two PhD projects, one at YKI with head supervision at KTH Surface and Corrosion Science and one at Mid-Sweden University / Digital Printing Center. The Troëdsson instrument was used early on in the project with publication and conference presentation in 2008 of inkjet ink penetration measurements. The same methodology is now used for a second key activity in the project. The total project budget is 13 MSEK and the budget at SP is 5 MSEK.

Asafs arbete behandlar vätskepenetration och kolloidkemi vid bläckstråletryckning. Bläckstråleskrivare används på hemmakontoret och i industriell skala och kräver god kontroll av droppstorlek, vätning och vätskepenetration. Asaf har utvecklat mätmetodik för att studera fenomenen vid relevant längd- och tidsskala, sedan tillämpat på modellmaterial och med enkla vätskor samt tagit fram teori som med hjälp av dimensionslösa parametrar och skalningslagar bekräftar experimenten. Dessa skalningslagar tillämpas sedan på ett komplext material (dvs. papper) med komplexa vätskor (dvs. tryckfärg). Slutligen förklaras med kolloidkemi och jonspecifika effekter vad som händer i tryckfärger för en nyare typ av industriell ytbehandling med tillsats av divalenta salter på papper.

Fakultetsopponent: Professor Douglas Bousfield, University of Maine, USA. Handledare: Per Claesson (KTH, SP) och Agne Swerin (SP)

Effect of local curvature and chemical heterogeneities of particulate surfaces on interaction forces (ended 2012)

This is a PhD project started 2008 and successfully defended in November 2012, financed by Omya AG, Switzerland and partly by SK-funding at YKI through funding from RISE AB. The student has been Petra Hansson. The Troëdsson instrument turned into a key equipment in the project in which the air/vapor and wetting layers was imaged spectroscopically for hydrophobic and superhydrophobic surfaces. The turnover for the five-year project was 4 MSEK. The collaboration with Omya AG will now continue in a postdoc project at YKI/KTH for Petra Hansson starting January 2013, see below. The thesis title was “Hydrophobic surfaces: Effect of surface structure on wetting and interaction forces”. The dissertation was Friday November 2 and the opponent was Assoc. Prof. Adam C. Simonsen, University of Southern Denmark, Odense.

Renewable Functional Barriers (ended 2012)

The project started in 2008 and also belongs to the Forest-based Industry Sectoral Programme at VINNOVA (Branschforskningsprogrammet för trä-, möbel- och skogsindustri). Renewable and functional barrier materials will be processed, functionalized and investigated in a four-year project with VINNOVA and industry. The Troëdsson instrument is used to image the chemical heterogeneity of barrier materials. The total project is 30 MSEK and the budget at YKI is 1,8 MSEK.

Better pitch control additives – an AFM investigation (ended 2011)

This is a VINNOVA-funded project through the Forska&Väx program for SME (Small and Medium-sized Enterprises). A project was run during 2009-2011 together with BIM Kemi in Stenkullen and characterization of pitch surfaces was made using Raman spectroscopy. The budget was 1 450 kSEK.

Instrumentation methodology – Measurement of water content using confocal Raman

The best spatial and depth resolution is achieved by using an oil immersion objective. In this technique, the sample is covered with a cover slip on which an oil droplet is placed. The

objective is then immersed into the oil. For investigation a solid sample, the air gap between the bottom glass/air interface has to be filled with a liquid in order to avoid total reflection of the incoming laser. For paper samples, silicon oil is used for this purpose since it does not react with the sample. Biological samples like tissue have to be investigated with water. This leads to the disadvantage that it cannot be distinguished between water being present in the sample and water used as immersion liquid. This can be overcome by using heavy water (D_2O) between the sample and the cover slip. Replacing the hydrogen atoms by the heavier isotope deuterium results in moving the Raman signal from the interval $3100-3700\text{ cm}^{-1}$ to $2200-2800\text{ cm}^{-1}$, a range at which no other Raman signal appear. As a result, the exchange of the water bound in the sample with the heavy water from the surrounding can be observed.

Instrumentation methodology – Time resolved measurements

Another application of the Raman microscope was the monitoring of the Raman signal dynamic processes. Even if similar measurements were performed earlier, they can be improved by using the EMCCD. Raman spectroscopy is an excellent method for distinguishing between the aggregate states frozen and liquid and even a mixture of both. Combined with the great resolution of the confocal microscope, the freezing and melting of liquids on surfaces can be monitored. This is used in one of YKIs major projects TopNANO.

The proof of principle for studying wetting and spreading of liquids on a surface by confocal Raman microscopy was shown. For the proof-of-principle water was pipetted onto a filter paper but a picoliter dispenser (Microdrop) can also be mounted at a defined distance of the optical focus of the objective (see figure below). Droplets with a defined volume are impinged onto the surface while Raman spectra are recorded continuously.

New uses of functional calcium carbonates (run during 2013)

The aim of this postdoc project is to exploit the possibilities of using calcium carbonate minerals in new uses. Involved personnel were Petra Hansson, Agne Swerin, YKI, Esben Thormann, KTH, Patrick Gane and Joachim Schölkopf, Omya.

Surface spectroscopy of new functional calcium carbonates (new 2014)

The aim of this postdoc project is to understand using calcium carbonate minerals in new applications. Involved personnel are Petru Niga, Magnus Jonsson, Per Claesson, Agne Swerin, Patrick Gane and Joachim Schölkopf, Omya.

Optimized aggregation for increased dewatering and reduced pressure loss during fibrous biomass conversion (new 2014)

We assess a new concept for flocculation for fibrous and elongated particle suspensions. Initial laboratory results for fiber suspensions show that the potential is as much as a 50 % increase in dewatering capacity and a decrease in pressure loss in pipe flow (measured as yield stress) to a third. The flocculation concept is applicable to any flow and dewatering situation in which there is a significant amount of fibrous or elongated particles. The concept would require a new design of some of the machinery equipment such as stirred tanks in combination with pipe flow but the potential is great. The foreseen industrial applications are primarily in biomass conversion but could also be in other sectors, such as waste water treatment, or any application rich in fibrous material and where there are substantial bottlenecks in dewatering capacity, and high pressure loss in pipe flow resulting in the need to use low solids with loss in production efficiency. We have so far performed a pre-study together with two industrial companies and started a postdoc project of Asaf Oko together with KTH Mechanics (KTH postdoc Jordan MacKenzie) on rheology and flow of fibrous suspensions with funding from Bo Rydin Foundation.

4.1. Publications and conference lectures

Leijonmarck, Simon; Cornell, Ann; Danielsson, Carl-Ola; Åkermark, Torbjörn; Brandner, Birgit D; Lindbergh, Göran

Electrolytically assisted debonding of adhesives: An experimental investigation

International Journal of Adhesion and Adhesives 32, 39-45, 2012

Hansson, Petra M; Swerin, Agne; Schoelkopf, Joachim; Gane, Patrick A C; Thormann, Esben

Influence of surface topography on the interactions between nanostructured hydrophobic surfaces, Langmuir 28 (21), 8026-8034, 2012

Hansson, PM; Hormozan, Y; Brandner, BD; Linnros, J; Claesson, PM; Swerin, A; Schoelkopf, J; Gane, PAC; Thormann, E

Effect of surface depressions on wetting and interactions between hydrophobic pore array surfaces, *Langmuir* 28 (30), 11121-11130, 2012

Hansson, Petra

Hydrophobic surfaces: Effect of surface structure on wetting and interaction forces
KTH Royal Institute of Technology, School of Chemical Science and Engineering (CHE), Chemistry, Surface and Corrosion Science, Stockholm; YKI, Institute for Surface Chemistry, Stockholm, 2012. Doctoral thesis. Supervisors at KTH and YKI: Per Claesson, Agne Swerin

Brandner B., Sundin M. Swerin A.

Real-time wetting, spreading and sorption measured by confocal Raman microscopy
8th International Paper and Coating Chemistry Symposium, 10-12 June 2012, Stockholm, Sweden.

Hansson P., Thormann E., Brandner B., Claesson P., Swerin A., Schoelkopf J., Gane P.

Influence of surface roughness and structure on forces between hydrophobic surfaces
8th International Paper and Coating Chemistry Symposium, 10-12 June 2012, Stockholm, Sweden.

Asaf Oko, Agne Swerin, Kjell Andersson, Erik Lindgren and Per Claesson

Water based pigment inkjet inks' response to cationic additives
8th International Paper and Coating Chemistry Symposium, 10-12 June 2012, Stockholm, Sweden. Poster presentation

Chen Gällstedt, Haiyan; Javed, M A; Mira, Isabel; Lindqvist Hoffman, Josefina; Swerin, Agne; Hedenqvist, Mikael S; Dubreuil, Marjorie; Vangeneugden, Dirk; Gällstedt, Mikael; Johansson, Kenth S

Surface modification of renewable wheat gluten and starch-based films for improved water resistance. Proceedings/Extended abstract. IPCCS 2012. 8th International Paper and Coating Chemistry Symposium, Stockholm, Sweden, 10-14 June 2012

Sedighi, Maziar; Claesson, Per M; Wålinder, Magnus, Swerin, Agne
Comparison of different methods for studying wood wettability and liquid penetration
Oral presentation. Eighth International Symposium on Contact Angle, Wettability and
Adhesion, Quebec City, Canada, June 13-15, 2012

Sedighi, M; Claesson, P M; Wålinder, M; Swerin, A.
New approaches for studying wood wettability and liquid penetration by using Wilhelmy plate
method
Presentation. 8th Meeting of the Northern European Network for Wood Science and
Engineering (WSE), Kaunas, Lithuania, September 13-14, 2012

Thormann, Esben; Hansson, Petra; Swerin, Agne; Linnros, Jan
Interactions between topographically structured hydrophobic surfaces
Presentation. ECIS 2012: 26th Conference of the European Colloid and Interface Society,
Malmö, Sweden, September 2-7, 2012

Brandner, B., Hansson, P., Swerin, A., Claesson, P., Wåhlander, M., Schoelkopf, J., Gane, P.
Solvent segregation and capillary evaporation at a superhydrophobic surface investigated by
confocal Raman microscopy and force measurements
Soft Matter, 7 (3), 1045 – 1052 (2011)

Viivi Koivu
Experimental and Computational Micro-Characterization Techniques in Wood Mechanics
STSM Research Report, University of Jyväskylä, Finland (2010)

Brandner, B., Swerin, A., Alvarez, G.
Wet and dry adhesion in fiber-fiber joints and chemical / Topographical mapping of
lignocellulosic fiber surface
7th International Paper and Coating Chemistry Symposium (IPCCS), Hamilton, Canada, 10-12
June 2009, pp 73-77.

Brandner, B., Swerin, A, Alvarez G.

Wet and dry adhesion in fiber-fiber joints and chemical / Topographical mapping of lignocellulosic fibre surface

International Mechanical Pulping Conference (IMCP), Sundsvall, Sweden, 31 May – 4 June 2009, pp 304-308.

Swerin, A., Brandner, B., Wallqvist, V. and Wåhlander, M.

Probing Molecular, Nanoscale and Adhesive Forces Related to Fiber-Fiber Bonding and Optimized Surface Interactions

2009 International Conference on Nanotechnology for the Forest Products Industry, June 23–26, 2009, Edmonton, AB, Canada.

Aggregation of inkjet ink components by Ca and Mg ions in relation to colorant pigment distribution in paper

By: Oko, Asaf; Swerin, Agne; Brandner, Birgit D.; et al.

COLLOIDS AND SURFACES A-PHYSCOCHEMICAL AND ENGINEERING ASPECTS
Volume: 456 Pages: 92-99 Published: AUG 20 2014

Effects of water gradients and use of urea on skin ultrastructure evaluated by confocal Raman microspectroscopy

Alber, C.; Brandner, B. D.; Bjorklund, S.; et al.

BIOCHIMICA ET BIOPHYSICA ACTA-BIOMEMBRANES Volume: 1828 Issue: 11
Pages: 2470-2478 Published: NOV 2013

In situ confocal Raman micro-spectroscopy and electrochemical studies of mussel adhesive protein and ceria composite film on carbon steel in salt solutions

By: Zhang, Fan; Brinck, Tore; Brandner, Birgit D.; et al.

ELECTROCHIMICA ACTA Volume: 107 Pages: 276-291 Published: SEP 30 2013

Biodegradation of Single-Walled Carbon Nanotubes by Eosinophil Peroxidase

By: Andon, Fernando T.; Kapralov, Alexandr A.; Yanamala, Naveena; et al.

SMALL Volume: 9 Issue: 16 Pages: 2721-2729 Published: AUG 26 2013

Study of the porous structure of white chocolate by confocal Raman microscopy

By: Dahlenborg, Hanna; Millqvist-Fureby, Anna; Brandner, Birgit D.; et al.

EUROPEAN JOURNAL OF LIPID SCIENCE AND TECHNOLOGY Volume: 114 Issue: 8
Pages: 919-926 Published: AUG 2012

Spatial imaging and evaluation of humectants impact on stratum corneum hydration with
confocal Raman microspectroscopy

By: Alber, C.; Brandner, B. D.; Billsten, P.; et al.

INTERNATIONAL JOURNAL OF COSMETIC SCIENCE Volume: 34 Issue: 4 Pages:
359-359 Meeting Abstract: 005 Published: AUG 2012

Effect of Surface Depressions on Wetting and Interactions between Hydrophobic Pore Array
Surfaces

By: Hansson, Petra M.; Hormozan, Yashar; Brandner, Birgit D.; et al.

LANGMUIR Volume: 28 Issue: 30 Pages: 11121-11130 Published: JUL 31 2012

Solvent segregation and capillary evaporation at a superhydrophobic surface investigated by
confocal Raman microscopy and force measurements

By: Brandner, Birgit D.; Hansson, Petra M.; Swerin, Agne; et al.

SOFT MATTER Volume: 7 Issue: 3 Pages: 1045-1052 Published: 2011

Aggregation of inkjet ink components by Mg²⁺ and Ca²⁺ salts in relation to inkjet print
quality

88th ACS Colloid and Surface Science Symposium, UPenn, Philadelphia, June 22-25, 2014

Colloidal and Surface Forces 3: Films

Asaf Oko, Agne Swerin, Wayne Cook, Douglas Bugner and Per M. Claesson

SP and KTH, Stockholm, Sweden, Kodak, Rochester, NY and Dayton, OH, USA

Novel Single and Multi-cycle Wilhelmy Plate Methods for Wetting, Swelling and Sorption of
Porous Materials such as Wood

88th ACS Colloid and Surface Science Symposium, UPenn, Philadelphia, June 22-25, 2014

Maziar Sedighi, Agne Swerin, Magnus Wålinder and Per M. Claesson

Adhesion, friction and bonding in cellulosic fiber-fiber joints

88th ACS Colloid and Surface Science Symposium, UPenn, Philadelphia, June 22-25, 2014

Agne Swerin and Birgit D. Brandner

Long-range interaction forces between hydrophobic and superhydrophobic surfaces studied by AFM colloidal probe microscopy

88th ACS Colloid and Surface Science Symposium, UPenn, Philadelphia, June 22-25, 2014

Petra M. Hansson, Agne Swerin, Martin Wähländer, Esben Thormann and Per M. Claesson

Imbibition and evaporation of water droplets on paper and solid substrates

Oko, A., Swerin, A., Claesson, P. M., Journal of imaging science and technology, 2011, 55, 01020/1-01020/6.

Infiltration and dimensional scaling of inkjet droplets on thick isotropic porous materials

Oko, A., Martinez, D. M., Swerin, A., Microfluidics and Nanofluidics, 2014, 17, 413-422.

Asaf Oko

Spontaneous imbibition and colloidal aspects of inkjet printing

KTH Royal Institute of Technology, School of Chemical Science and Engineering (CHE), Chemistry, Surface and Corrosion Science, Stockholm; SP Chemistry, Materials and Surfaces, Stockholm, 2014

Doctoral thesis. Supervisors at KTH and SP: Per Claesson and Agne Swerin

4.2. Publications and conference lectures in preparation

Wähländer, M., Hansson-Mille, P. and Swerin, A. Superhydrophobicity: Cavity growth and wetting transition Journal of Colloid and Interface Science (submitted)

Brandner, B., Swerin, A., Alvarez, G. Adhesion and chemical mapping of lignocellulosic fibre-fibre joints by means of AFM and Raman microscopy. Manuscript

Infiltration and dimensional scaling of inkjet droplets on papers with different surface chemistry. Oko, A., Swerin, A., Niga, P, Claesson, P. M., Manuscript.

Sedighi et al., Submitted an abstract in MRS 2015 (Material Research Society spring meeting) with title of “Wood Surface Modification by Combining Plasma Coating and Liquid Flame Spray Methods: Temperature-Wetting Properties”

Sedighi et al., “Wettability and swelling of acetylated and furfurylated wood analyzed by multicycle Wilhelmy plate method” submitted 140703, revised 141110.

Sedighi et al., “Supercooled water wettability on modified wood surfaces”

Sedighi et al., “Wood Surface Modification by Combining Plasma Coating and Liquid Flame Spray Methods: Wetting Properties and characterization”

4.3. Other

Svensk patentansökan nr 1450759-4, inlämnad 18 juni 2014 av SP Sveriges Tekniska Forskningsinstitut. Uppfinnare: Agne Swerin och Gilbert Carlsson

5. Appendix 1: Maziar Sedighi's PhD project study plan



Page 1 of 4

Individual Study Programme – Postgraduate Students

School	Unit	Date
CHE	Surface and corrosion	2014-03-25

General

Student's name	Personal ID number
Maziar Sedighi Moghaddam	810527-7951
E-mail address	Telephone number
mazism@kth.se , maziar.sedighi@sp.se	070-2353023
Admitted on date	Total planned study period, years/months
2011-05-02	4years/48months-ending 2015-09-01
Admitted to postgraduate studies; desired degree	<input type="checkbox"/> Licentiate <input checked="" type="checkbox"/> Doctor
Degree designation (if not ... of "teknologie")	<input type="checkbox"/> Preliminary <input checked="" type="checkbox"/> Decided
Tekn. Dr.	
Postgraduate subject area	Specialisation, if any (see study plan)
Surface Chemistry	Sustainable wood modification
Principal Supervisor	Telephone
Prof. Agne Swerin	010 516 60 31
Supervisor	E-mail address
Prof. Per Claesson	percl@kth.se
Supervisor	E-mail address
Prof. Magnus Wålinder	Magnus.Walinder@byv.kth.se

Type of financing of studies		
<input type="checkbox"/> Employment as doctoral student	<input type="checkbox"/> Other KTH employment	
<input type="checkbox"/> Scholarship	<input checked="" type="checkbox"/> Industrial doctoral student	
<input type="checkbox"/> Study grant	<input type="checkbox"/> Other, to be described: Industrial PhD-student employed at YKI	
Intended degree of study effort during the next 12-month period	Achievements so far, percentage of total degree requirements	Approx. date of degree diploma
100%		Lic: Doctor: 2015-09-01

Student is obliged to *report at once to his/her principal supervisor* whether any circumstances should occur that may affect his/her ability to complete successfully the study programme as indicated below.

Performance / achievement requirements

Courses up to graduation

1) If courses are planned at other universities, indicate where!
2) Courses to be completed in next 12 months.

Courses to be given credit for				
This applies to courses taken before present admittance to postgraduate studies.				
Course code	Course name	University 1)	Credits	Completed (date)
Completed courses				
FKF3260	Characterization Methods for Fibre and Polymer Science	KTH (PhD level)	7.5 hp	2012-06-12

FAF3301	Wood chemistry, Biocomposites and Building Materials	KTH (PhD level)	7.5 hp	2012-09-11
F3B5219	Research ethics	KTH (PhD level)	1.5 hp	2012-11-15
FDS3102	Writing Scientific Articles	KTH (PhD level)	5.0 hp	2013-02-20
F3B5282	Advanced Surface and Colloid Chemistry	KTH (PhD level)	15.0 hp	2013-04-05
-----	Practical infrared and Raman spectroscopy	SU (PhD level)	5.0 hp	2013-05-06
FKD3090	Research frontiers in surface and corrosion sci.	KTH (PhD level)	4.0 hp	2013-05-06
F3B5209	Theoretical surface chem.: surface forces	KTH (PhD level)	7.5 hp	2013-12-19
Planned courses				
Course code	Course name	University 1)	Credits	Planned Completion
KF3240	The Chemistry of wood	KTH (PhD level)	10 hp	2014-06-30

Outline plan of thesis work

Outline plan and also detailed plan of time period up to next revision of student's individual study programme

The project is concerned with wettability, sorption and permeability on wood with emphasis on modified wood

- 1- Developing new methods for wettability study of wood samples by using Wilhelmy plate method and sessile drop method (Paper 1 and 2)
- 2- Applying these methods to study dynamic wettability of different wood samples (modified and unmodified) (Paper 2 and 3)
- 3- Correlating the wetting properties to surface chemical composition (studying by XPS imaging) and microstructure (studying by X-Ray tomography) with emphasis on pine sapwood/heartwood interface (Paper4)
- 4- Combining LFS (liquid flame spray) method and polymer plasma coating to create superhydrophobic surfaces of wood, wetting (paper5) and freezing (paper6) measurements
- 5- Micro structure study of modified wood by X-Ray tomography (paper7)

Plan for supervising effort

Planned supervision meetings with Profs. Swerin, Claesson and Wålinder biweekly

Results from previous study efforts

Magazine articles, contributions during conferences; other publications

- 1- Paper 1: *"Comparison of different methods for studying wood wettability and liquid penetration"* Wood Science and Technology 48(1)161-176.
- 2- Paper 2: *"Multicycle Wilhelmy Plate Method for Wetting Properties, Swelling and Liquid Sorption of Wood"* Langmuir 29 (39):12145-12153.
- 3- Paper 3 with title of *"Wettability and swelling of acetylated and furfurylated wood analyzed by multicycle Wilhelmy plate method"* plan to be submitted 140430
- 4- Plan to submit two more papers based on the experimental results until next year
- 5- Oral presentation at Northern European Network for Wood Science and Engineering (WSE) September 13 - 14, 2012, in Kaunas, Lithuania with title of "New approaches for studying wood wettability and liquid penetration by using Wilhelmy plate method"
- 6- Oral presentation at Northern European Network for Wood Science and Engineering (WSE), September 10 - 11, 2013, in Hannover, Germany with title of "Development of a multi-cycle Wilhelmy plate method for studying dynamic wettability and swelling behavior of wood"

<p>7- Oral presentation at the 7th European conference on wood modification (ECWM7), 10-12 Mar., 2014, in Lisbon, Portugal with title of "<i>Wettability and swelling of acetylated and furfurylated wood analyzed by multicycle Wilhelmy plate method</i>"</p> <p>8- Submitted an abstract in ACS 2014 colloid and surface science symposium with title of "<i>Novel single and multi-cycle Wilhelmy plate methods for wetting, swelling and sorption of porous materials such as wood</i>"</p> <p>Teaching effort and/or other departmental or School duties As an industrial doctoral student, Maziar does not have any teaching duties. However Maziar was lab assistance at a course "<i>Nanostructures Materials</i>" given by Per Claesson in Nov. and Dec. 2013</p>
<p>Intended goal of education Written assessment of how the required educational goals have been fulfilled in accordance with "KTH:s mål för utbildning på forskarnivå", also taking the subject area study programme into account.</p> <p>The first goal of this study is developing new approaches to wettability and sorption study of wood surfaces. The second goal is realizing how the components in the impregnation liquid affect sorption rate Another purpose of this PhD work is correlate the wettability properties of the wood samples to both chemical composition and morphological properties of the wood</p>
<p>Follow-up of study effort during previous year Written evaluation; this should specify both research, postgraduate course and teaching efforts in the previous year, as compared with that year's study programme. Indicate also level of activity and follow-up of the actual extent of given supervising effort.</p> <p>Maziar has followed most of the planned courses given in last year study plan. He is going to finish his courses in till end of Jun. New approaches have been successfully developed for wettability study of swellable surfaces (e.g. wood) by using Wilhelmy plate method. The first two papers have been written based on these results. He is going to submit the paper 3 about applying these new techniques on modified wood soon. XPS analysis has been done based on the interface of wood sapwood and heartwood samples. (paper4) The superhydrophobic wood surfaces have been made using liquid flame spray technique and plasma coating. (paper 5&6) Maziar's application to Trees4Future program has been accepted to do X-Ray tomography measurements on wood samples at Ghent University (Belgium) as an internship program. He will be there from 26 Mar. to 20 Apr. to investigate microstructure properties of modified wood samples (paper7), LFS and plasma coated wood samples (paper5) and pine sapwood/heartwood interface samples (paper4) by using X-Ray tomography technique.</p>
<p>Re students with KTH doctoral student employment SP employed PhD student follow doktorandstegen Achieved result as compared with "doktorandstegen" (the "doctoral ladder"): 80%-2014-05-01 Planned time of reaching next step of "doktorandstegen": -----</p>
<p>Planned extent of teaching effort, incl. type of same; also other duties at Department and/or School level, next year</p>
<p>School's commitments Place of work, access to special equipment etc. Laboratory available at KTH and SP, office space with internet connection of SP</p>
<p>Other information -----</p>
<p>Supervisors who have taken part in devising this study programme Prof. Agne Swerin, Prof. Per Claesson, Prof. Magnus Wålinder</p>

Individual study programme as first devised (original version)	Date 2011-05-18
Individual study programme updated	Date 2012-06-15 and 2013-04-30
Next programme update to take place not later than	Date 2015-04-30

6 Appendix 2 – Abstracts of Maziar’s Paper 1, 2 and 3

Langmuir

Article

pubs.acs.org/Langmuir

Multicycle Wilhelmy Plate Method for Wetting Properties, Swelling and Liquid Sorption of Wood

Maziar Sedighi Moghaddam,[†] Magnus E.P. Wälinder,[‡] Per M. Claesson,^{†,||} and Agne Swerin^{*,†,||}

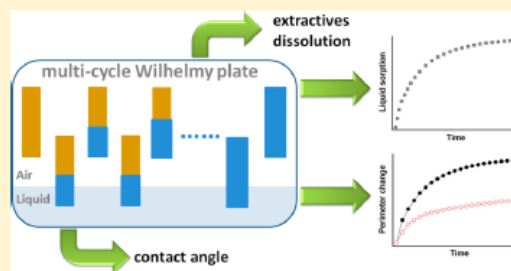
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Supporting Information

ABSTRACT: A multicycle Wilhelmy plate method has been developed to investigate wetting properties, liquid sorption, and swelling of porous substrates such as wood. The use of the method is exemplified by studies of wood veneers of Scots pine sapwood and heartwood, which were subjected to repeated immersion and withdrawal in a swelling liquid (water) and in a nonswelling liquid (octane). The swelling liquid changes the sample dimensions during measurements, in particular its perimeter. This, in turn, influences the force registered. A model based on a linear combination of the measured force and final change in sample perimeter is suggested, and validated to elucidate the dynamic perimeter change of wood veneer samples. We show that pine heartwood and pine sapwood differ in several respects in their interaction with water. Pine heartwood showed (i) lower liquid uptake, (ii) lower swelling, (iii) higher contact angle, and (iv) lower level of dissolution of surface active components (extractives) than pine sapwood. We conclude that the method is also suitable for studying wetting properties of other porous and swellable materials. The wettability results were supported by surface chemical analysis using X-ray photoelectron spectroscopy, showing higher extractives and lignin content on heartwood than on sapwood surfaces.



Wood Sci Technol (2014) 48:161–176
DOI 10.1007/s00226-013-0592-1

ORIGINAL

Wettability and liquid sorption of wood investigated by Wilhelmy plate method

Maziar Sedighi Moghaddam · Per M. Claesson ·
Magnus E. P. Wålinder · Agne Swerin

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Abstract The wettability of Scots pine veneers was investigated with different approaches using the Wilhelmy plate method. The probe liquids were water and octane, which differ; in that, water is able to swell the wood sample, whereas octane does not. Novel approaches based on the Wilhelmy plate method to study wettability, liquid penetration, and swelling behavior of wood veneers are introduced. First, immersion to constant depth was performed, and liquid uptake with time was evaluated. Different kinetic regimes, the fastest one associated with contact angle changes and the slowest regime associated with liquid sorption by capillary and diffusion, were observed. Two other approaches, imbibition at constant depth (with initial deeper immersion) and full immersion, were utilized in order to keep the contact angle constant during measurements. Dynamic wettability studies were done by a multi-cycle (10–20 cycles) Wilhelmy method. Based on this, the time-dependent swelling of wood and changes in sample perimeter could be obtained. Generally, water showed higher absorption than octane. In all wettability studies, and for both probe liquids, the penetration process starts with a fast initial sorption, which is followed by swelling in the case of water.

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**Wettability and swelling of acetylated and furfurylated wood
analyzed by multicycle Wilhelmy plate method**

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Abstract

A multicycle Wilhelmy plate method was applied to compare wetting, dimensional stability and sorption properties of a range of modified wood samples, obtained either by acetylation or furfurylation, with those of unmodified samples of the same wood species. Wettability measurements were performed with water and octane as swelling and non-swelling liquid, respectively. It was found that acetylation reduces the water up-take mainly by reducing the swelling. In contrast, furfurylation reduces both swelling and the void volume in the sample. To quantify the effect of the modification process of the wood properties we introduce two parameters, the "liquid up-take reduction" and the "perimeter change reduction", that can be determined from multicycle Wilhelmy plate measurements. **The results** suggest that the furfurylated wood with a higher level of weight percent gain (WPG) shows larger changes in wood surface, swelling and sorption properties than the acetylated wood.

Keywords: acetylation, contact angle, furfurylation, multicycle Wilhelmy plate, swelling, wettability, wood