Stockholm 29-2-2016

Till Åforsk Forskningsstiftelse

Härmed bifogas slutrapport för **Åforsk Project 2014:512 ”Bark Biorefinery – upscaling processes and new materials”.**

Vi ber att få framföra vårt stora tack till Åforsk för Barkbioraffinaderiprojektet som nu har examinerat ytterligare en Teknologie Dr, Dongfang Li.

Dr Lis avhandling bifogas till slutrapporten.

Bästa hälsningar

Monica Ek

Professor Träkemi

KTH, Skolan för Kemivetenskap, Institutionen för Fiber och Polymerteknologi

Final report

Åforsk Project 2014:512

Bark Biorefinery – upscaling processes and new materials

Monica Ek

Dongfang Li

Rosana Moriana Torro

Division Wood chemistry and Pulp Technology

Dept Fiber and Polymer Technology

School of Chemical Science and Engineering

Summary and Acknowledgements

The present project, the continuation of Åforsk project 2013-448, has focused on getting a deeper fundamental knowledge of the bark biorefinery to create demonstrators and also possibilities to upscale the fractionation processes. Moreover an important part has been the transfer of the obtained knowledge externally to the scientific community and the public.

Åforsk Foundation is acknowledged for financing support to Dr Dongfang Lis PhD thesis and Dr Rosana Moriana Torros Post Doc position at the Division of Wood Chemistry and Pulp Technology.

Aim of the project

The project "Bark Biorefinery" has focused on a novel processes for fractionation of bark components. The target has primarily been to extract bark polysaccharides and extractives such as suberin based epoxy fatty acids, and evaluate their properties in different packaging applications.

There has also been focus on the knowledge-transfer, both to the parallel project Wood Wisdom ERANET project Wood Based Materials and Fuels, "Wobama" and externally to society and stakeholders.

Project organization

The project has been conducted as cooperation between the academic partners at KTH and the results have been reported and discussed with the parallel Wood Wisdom ERANET project Wobama, where the industrial partners Andritz, Akzo Nobel, Metso Fiber, OrganoClick, Processum and Stora Enso, has contributed as an advisory partner group.

Academic thesis and dissertation

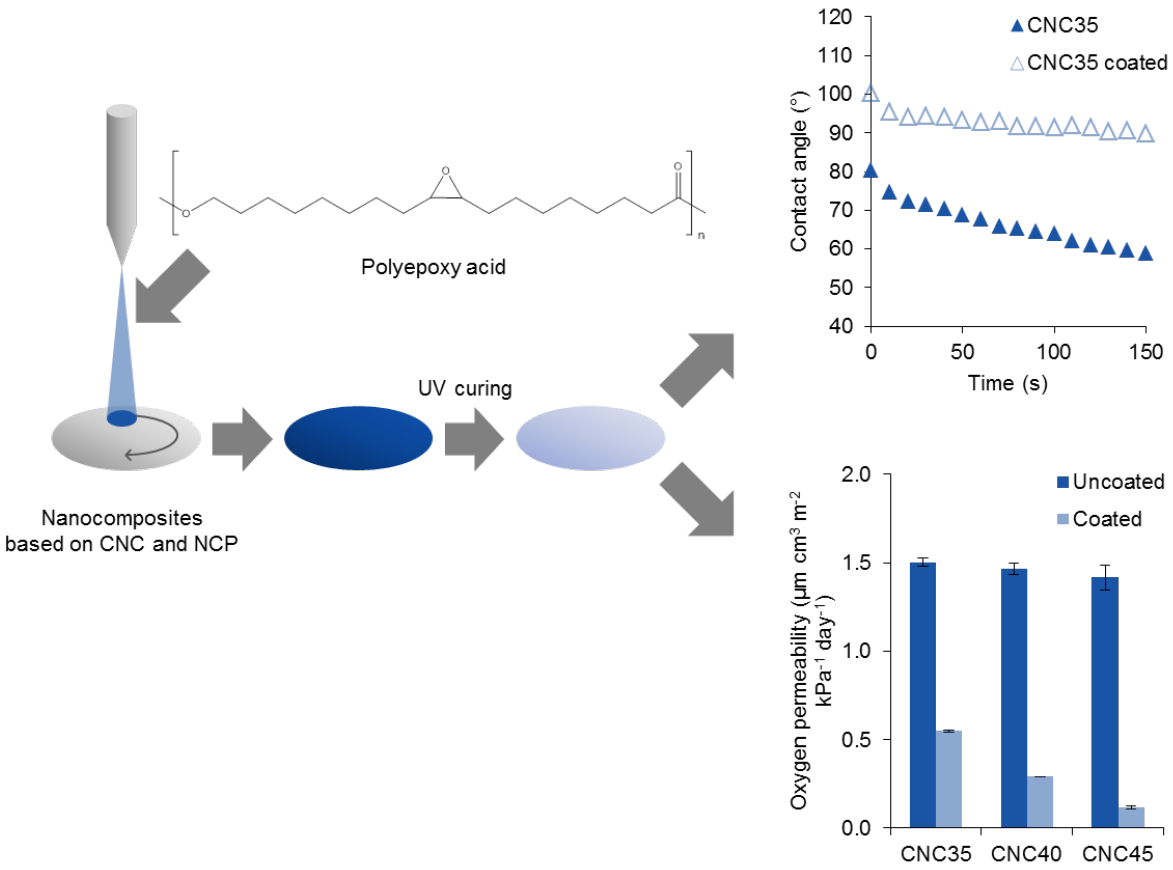
Dongfang Li has defended his thesis titled *"Wood Cellulose activation, dissolution and hydrophobization" (2015)* which is based on his work in the previous Wood Wisdom project Wood Based Materials and Fuels (Wobama) and the present project.

Summary of achieved results

From forest residues to hydrophobic nanocomposites with high oxygen-barrier properties

A biorefinery of forest resources should be able to convert all components of trees, including the bark and other types of forest residues, into value-added products. In Dongfang Li's work, a suberin monomer, *cis*-9,10-epoxy-18-hydroxyoctadecanoic acid (hereafter denoted as epoxy acid), was isolated from the outer bark of birch with high purity (94%) and good yield (8 wt% of the dry weight of bark). Polyepoxy acid (PEA) was prepared through a lipase-catalyzed polymerization of the epoxy acid.

Nanocomposites consisting of non-cellulosic polysaccharides (NCPs) isolated from Norway spruce bark and cellulose nanocrystals (CNCs) isolated from the logging residues of Norway spruce were prepared, which showed competitive thermo-mechanical properties. However, these materials were hygroscopic, which is a crucial obstacle with respect to certain applications such as packaging materials. In this study, the nanocomposites were surface-coated with crosslinked PEA to improve the properties.



As a result, all of the PEA-coated nanocomposites were hydrophobic. At 50% and 80% relative humidity, they showed high oxygen-barrier properties that were comparable to or even better than those of some renewable materials such as xylan-, galactoglucomannan- and nanofibrillated cellulose-based films and synthetic materials such as polyvinylidene chloride and polyamide. In addition, the coatings did not significantly compromise the original levels of strength and rigidity of the nanocomposites.

Therefore, we demonstrated that the polyepoxy acid could be used as an interesting potential chemical to solve the problems arising from the moisture sensitivity of polysaccharide-based materials. More importantly, we demonstrated that residues from forest-related industries could be used to prepare renewable materials with versatile functionalities. Our work meets the requirement of the biorefinery concept.

This study was included in Dongfang Li's doctoral thesis that was defended on 2015-06-05.

References

Doctoral Thesis *Wood Cellulose Activation, Dissolution and Hydrophobization; Dongfang Li, KTH, 2015, TRITA-CHE Report 2015:16*

1. Production of dissolving grade pulps from wood and non-wood paper-grade pulps by enzymatic and chemical pretreatments
   Dongfang Li, David Ibarra, Viviana Köpcke, Monica Ek. (2012) In: Functional Materials from Renewable Sources. Eds. Liebner, F., Rosenau, T. American Chemical Society, Washington, DC. pp.167-189.
2. Pretreatment of softwood dissolving pulp with ionic liquids
   Dongfang Li, Olena Sevastyanova, Monica Ek. (2012) Holzforschung 66:935-943.
3. ***Hydrophobic materials based on cotton linter cellulose and an epoxy-activated polyester derived from a suberin monomer***
   Dongfang Li, Tommy Iversen, Monica Ek. (2015) Holzforschung 69:721-730.
4. ***Treatment of a cellulose fiber surface with a suberin monomer-derived polymer***
   Dongfang Li, Tommy Iversen, Monica Ek. (2015) Polymers from Renewable Resources 6:75-90.
5. ***From forest residues to hydrophobic nanocomposites with high oxygen-barrier properties***
   Dongfang Li, Rosana Moriana, Monica Ek. (2015) Nordic Pulp and Paper Research Journal, under revision
6. WOBAMA – Wood based materials and fuels
   Monica Ek, Christine Chirat, Linda Fogelström, Tommy Iversen, Dongfang Li, Eva Malmström, Emelie Norström, Herbert Sixta, Lidia Testova, Terhi Toivari, Dariusz Wawro. (2014) Cellulose Chemistry and Technology 48:773-779.
7. Björkbark gör cellulosa vattenavstötande, Dongfang Li. (2014) Svensk papperstidning 9:36-37.

Bold = present project

Conference participation

1. SPCI & Friends, 26 May 2015, Stockholm, Sweden. An oral presentation (so-called "elevator pitch") "WOBAMA – Wood based materials" and more specifically, my project was given.
2. The 6th Workshop on Cellulose, Regenerated Cellulose and Cellulose Derivatives, 11-12 November 2014, Karlstad, Sweden. An oral presentation "WOBAMA" was given.
3. The 4th Avancell Conference, Chalmers University of Technology, 7-8 October 2014, Gothenburg, Sweden. A poster "Hydrophobic materials based on cellulose and a suberin monomer" was presented.

4. Marcus Wallenberg Prize Event Special Sessions for Younger Researchers and Scientists, 22-23 September 2014, Stockholm, Sweden. A poster "Hydrophobic materials based on cellulose and a suberin monomer" was presented.
5. The 13th European Workshop on Lignocellulosics and Pulp (EWLP2014), 24-27 June 2014, Seville, Spain. An oral presentation "Polyesters and composites based on birch suberin" was given.
6. The 5th Nordic Wood Biorefinery Conference (NWBC2014), 25-27 March 2014, Stockholm, Sweden. A poster "Polyesters and composites based on birch suberin" was presented.

Summary Bark Biorefinery - Upscaling Processes and new Materials

From forest residues to hydrophobic nanocomposites with high oxygen-barrier properties

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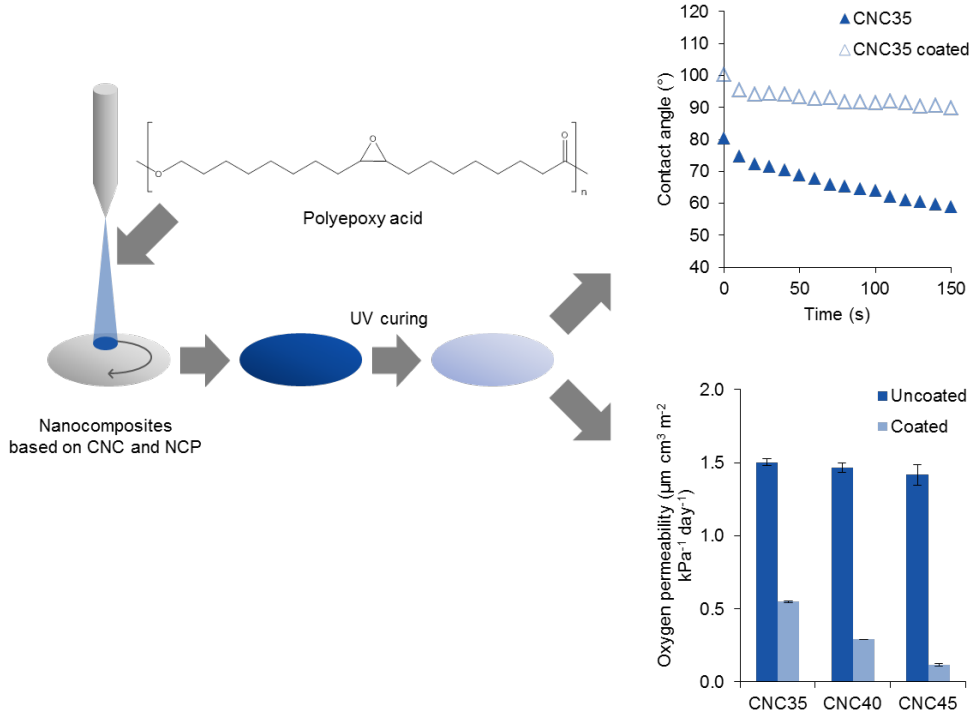

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