

Final report for SNS research projects

Submit the report to sns@slu.se by 24:00 CET, 1st of September, 2022, at the latest.
The report should not exceed 3500 words (including words in the template).

Please adjust the size of the box according to the length of your answer.

1. Project title:	Liberation and solution properties of wood hemicelluloses towards surface active molecules (HEMISURF) with funds from SNS – Nordic Forest Research.
2. Reporting year:	2019-2022 (adapted end-date is 2022-July-31)

3. Project coordinator:	Tiina Nypelö
Email:	Tiina.nypelo@chalmers.se
Address:	Kemivägen, 41296 Gothenburg, Sweden

Activity report

4. Provide a project summary, including:
a) The purpose of the project/main problems /hypothesis addressed The aim and continuous agenda of the SNS Hemisurf project has been to bring together and progress research topics related to wood hemicelluloses in the Nordic countries. Hemicelluloses are central polysaccharides that are abundant in wood as well as in crops. In this consortium the research items have been: • Liberation of wood hemicelluloses • Oxidation and modification of hemicelluloses towards surface activity • Demonstration of surface active hemicellulose grades for emulsifications The principal investigators (PIs) were: • Tiina Nypelö at Applied Chemistry, Department of Chemistry and Chemical Engineering, Chalmers University of Technology, Gothenburg, Sweden (CHA) • Kirsi S. Mikkonen: Department of Food and Nutrition, University of Helsinki, Helsinki, Finland (HEL) • Bjørge Westereng at Faculty of Chemistry, Biotechnology and Food Science, Norwegian University of Life Sciences, Norway (NMBU) b) A short description of the main activities of the project Meetings The first consortium meeting was held via skype on 22.01.2019. First in person meeting in Helsinki 15.8.2019: https://blogs.helsinki.fi/foodmaterialsscience/2019/09/09/hemisurfing-in-helsinki/. Visit of a student from NMBU to HEL took place in 2019 for emulsification tests of mannans from spruce. A report on that can be found at: https://blogs.helsinki.fi/foodmaterialsscience/2019/04/02/emulsions-from-norway-spruce-started-the-hemisurf-project/. During the project, the consortium has gathered together using online meeting platform zoom approximately every three months. Due to the travel restrictions during 2020-2021, the consortium was not able to meet in person during that time of the project. The coordinator Tiina Nypelö visited HEL on 7.10.2021 to discuss emulsification experiments and future collaboration possibilities. Dissemination The project has resulted in 4 original scientific publications or manuscripts, 1 review article manuscript (see Section 5) and attendance in scientific conferences and events (See Section 6). The project has contributed to 1 licentiate thesis at Chalmers and to 2 MSc thesis at NMBU (Section 5). The consortium has prepared a policy brief <i>Wood hemicelluloses for food and feed in the Nordic countries</i>. Research The work has been centered around oxidative modification of low and high degree of polymerization hemicelluloses, their further functionalization to be surface active and investigation of stabilization of emulsions using the hemicelluloses. The oxidation experiments revealed challenges of degradation and low yield (40%) with the short hemicellulose fractions, and the conditions were adapted to be milder. For identifying the degree of oxidation, it

was revealed that using the common analysis by monitoring consumption of the reagent is not always accurate and needs to be combined with other techniques. This is reported in Palasingh et al. 2022 (Modification of xylan via an oxidation–reduction reaction. *Carbohydrate Polymers*, 119660).

Regarding the follow up modification, the chosen modification route was to attach groups to the polymers that can render them more oil-loving and hence exhibit better surface stability/emulsifying properties. One approach that has been tested is to introduce the carbonyl oxidations that is then further conjugated with e.g., a lipid to obtain interfacially active compounds. Work within two master thesis projects “Synthesis of xylan- based glycoconjugates” and “Coupling of aglycones to functionalized oligosaccharides” has focused on the modification and will continue in upcoming master student project beyond *Hemisurf*.

We have prepared emulsions using pressurized hot water extracted birch glucuronoxylans and spruce galactoglucomannans. The emulsions exhibit good physical stability and low viscosity, making them interesting materials for encapsulation of bioactive compounds.

c) Achieved targets and to what extent the research plan was fulfilled

The project targeted in advances (and collaboration) combining extraction-modification-utilization of wood hemicelluloses. We have progressed in each of the activities. We have written a contribution (as review article manuscript on 01092022) that discusses use of wood hemicelluloses in food and feed and the route that needs to be taken to bring the academic demonstrations into applications.

5. Published outputs achieved as a consequence of the project (peer-reviewed articles, other publications)

(The Hemisurf project team members are in bold)

Original research

- **Palasingh, C.**, Ström, A., Amer, H., **Nypelö, T.** (2021). Oxidized xylan additive for nanocellulose films–A swelling modifier. *International Journal of Biological Macromolecules*, 180, 753-759.
- **Palasingh, C.**, Nakayama, K., **Abik, F.**, **Mikkonen, K.S.**, Evenäs, L., Ström, A., **Nypelö, T.** (2022) Modification of xylan via an oxidation–reduction reaction. *Carbohydrate Polymers*, 119660.
- **Palasingh, C.**, Kargl, R., Schaubeder, J., Spirk, S., Ström, A., **Nypelö, T.** (2022) Influence of degree of oxidation on xylan water-solubility and film formation. *Manuscript*.
- Ho, T.M., **Abik, F.**, Hietala, S., Ferro, E.L., Pitkänen, L., Juhl, D.W., Vosegaard, T., Kilpeläinen, P.O., **Mikkonen, K.S.** Wood lignocellulosic stabilizers: Effect of their characteristics on stability and rheological properties of emulsions. *Cellulose* (under review).

Review articles

- **Abik, F.**, **Palasingh, C.**, **Bhattarai, M.**, **Leivers, S.A.**, Ström, A., **Westereng, B.**, **Mikkonen, K.S.**, **Nypelö.** Wood hemicelluloses and derivatives at interfaces - towards use in food and feed. *Manuscript*.

Dissertations

- Licentiate thesis: **Palasingh, C.** (2021). Polysaccharide thin film Studies-Adsorption of Oxidized Xylan on Cellulose. Chalmers Tekniska Högskola (Sweden).
- Master of Science theses: “Synthesis of xylan- based glycoconjugates” and “Coupling of aglycones to functionalized oligosaccharides”

6. Other practical outputs of the project (websites, policy recommendations, conferences, scientific meetings, large-scale project applications, research training etc.)

- <https://blogs.helsinki.fi/foodmaterialsscience/2019/04/02/emulsions-from-norway-spruce-started-the-hemisurf-project/>
- <https://blogs.helsinki.fi/foodmaterialsscience/2019/09/09/hemisurfing-in-helsinki/>
- European Polysaccharide Network of Excellence (EPNOE) international conference, October 11-15, 2021. Participation by Tiina Nypelö (Symposium co-organization: Characterisation of polysaccharides: problems and prospects. Talk: About water interactions and periodate oxidation of cellulose and xylan; Chonnipa Palasingh (poster presentation: Adsorption of oxidized xylan on cellulose – A thin film study).
- Nordic Polymer Days 2022, June 1-3, 2022. Tiina Nypelö co-organizer, Chonnipa Palasingh presented results about solubilization of wood xylan in water.

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- 17th Conference of the International Association of Colloid and Interface Scientists (IACIS), June 26-29, 2022. Felix Abik presented about the interplay of lignin and polysaccharide in the interfacial adsorption of wood xylan at the liquid-liquid interface.
- European Workshop on Lignocellulosic and Pulp, June 29-July 1, 2022. Tiina Nypelö presented results about solubilization of wood hemicellulose.
- You can find a popular science summary of the project and its achievements by the coordinator in https://www.youtube.com/watch?v=FMT_hXQxVP4&feature=youtu.be

7. How and within which areas was the project beneficial for the Nordic countries?

This project contributes to the hemicellulose research in the Nordic countries, and specifically in the field of food science.

8. Write a short (maximum 800 words) popular science piece for dissemination in SNS' various channels with *emphasis on application of results and benefits for the Nordic society*.

Provide pictures (size at least 500x500 pixels and resolution at least 72 pixels) as separate files (.jpg). Include caption to each picture and the name of the photographer.

We have been interested in progressing nature-based molecules, wood hemicelluloses, towards use in food and feed. The objective was to enable use of all of the wood biomass, instead of the current approach of using mainly the cellulose fraction. We have investigated modification of wood hemicelluloses of different chain lengths. We have found that the oxidative modification that we use may be detrimental to the small molecules and hence the existing procedures had to be modified. The next step in the modification route was to attach groups to the polymers that can render them more oil-loving and hence exhibit better surface stability and emulsifying properties. We have prepared emulsions using pressurized hot water extracted birch glucuronoxylans and spruce galactoglucomannans. The emulsions exhibit good physical stability and low viscosity, making them interesting materials for encapsulation of bioactive compounds.

Participation

9. Number of participants

Country	Young researchers / PhD students	Senior researchers	Stakeholders	Others (specify)	Gender			Total
					Women	Men	Other	
Denmark								
Finland	2	1			2	1		3
Iceland								
Norway	4	1			1	4		5
Sweden	1	1			2			2
...								
...								
...								
Total	7	3			5	5		10

10. List the participating institutes/sectors

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- Coordinator Tiina Nypelö at Applied Chemistry, Department of Chemistry and Chemical Engineering, Chalmers University of Technology, Gothenburg, Sweden (CHA)
- Kirsi S. Mikkonen: Department of Food and Nutrition, University of Helsinki, Finland (HEL)
- Bjørge Westereng at Faculty of Chemistry, Biotechnology and Food Science, Norwegian University of Life Sciences, Norway (NMBU)

Economic report

11. Received grant from SNS in total (SEK):

1050000

12. Transfer of SNS funds to project partners

Country	Partner organization	Sum (SEK)
Denmark		
Finland	Helsinki University	345000
Sweden		
Norway	Norwegian University of Life Sciences NMBU	345000
Iceland		
Total SUM		690000

13. Costs

	SNS funding	External funds*	Total*
Travel and hotel	171 705	95 360	267 065
Meeting costs	56 904	0	56 904
Consumables	286 564	407 540	694 104
Salary	522 858	8 617 462	9 140 320
Communication	0	0	0
Other costs (specify)	11 968	111 651	123 620
Total SUM (SEK)	1 050 000	9 232 013	10 282 013

* If possible, provide details otherwise summarize the total sum for external funds and total.

14. Economic result (deficit or surplus):

Balanced

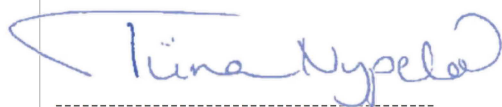
Optional: Comments to the economic reporting:

15. Submit a policy brief as a separate document. Provide pictures (size at least 500x500 pixels and resolution at least 72 pixels) in the policy brief as well as separate files (.jpg). Include caption to each picture, and the name of photographer.

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I hereby declare that the above statements are true to the best of my knowledge

Signature of the project coordinator



Chalmers University of Technology 30.8.2022

Signature

Institution

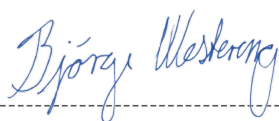
Date

Tiina Nypelö

Printed name

~~Signature of the department head at the department of the project coordinator~~

Third applicant's signature



Norwegian University of Life Sciences 31/8 2022

Signature

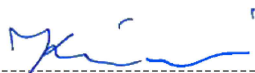
Institution

Date

Bjørge Westereng

Printed name

Second applicant's signature, place and date



University of Helsinki 30.8.2022

Signature

Institution

Date

Kirsi Mikkonen

Printed name

~~Third applicant's signature, place and date~~

Signature of the department head of the department of the coordinator



Chalmers University of Technology 220901

Signature

Institution

Date

Hanna Härelind

Printed name