

# Annual report for SNS research projects

Submit the report before March 1<sup>st</sup> to: [sns@slu.se](mailto:sns@slu.se)  
The report should not exceed 1500 words (including words in the template).

1. Project title:	<b>Valorization of wood biorefinery products into novel functional hydrocolloids (WOOD-PRO)</b>
2. Reporting year:	<b>2017</b>

3. Project coordinator:	Assistant Professor Kirsi S. Mikkonen
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## Activities during the reporting year:

4. Description of the activities during the reporting year:
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Research was carried out according to the project plan. Nanocelluloses and hemicelluloses with different structure, morphology, and purity were studied for the preparation of emulsions and gels. Hardwood nanocellulose and softwood hemicellulose were selected for the preparation of emulgels, in which the continuous phase of an emulsion was gelled to form an elastic network of hydrocolloids surrounding the dispersed phase: oil droplets. The functionality of nanocellulose and hemicellulose was tested at varying temperature and relative humidity. Storage tests were performed to reveal the long-term physical stability of the compositions.

Cellulose nanofibers have been prepared by means of ultrafine grinding approach from two different sources of raw material. First from carrot residue, where the purification was carried out prior to the mechanical fibrillation. Secondly, wood nanofibers were prepared using dissolving pulp as starting material. The characterization during and after fibrillation included optical microscopy, viscosity measurements, and the measured energy demand of the mechanical grinding.

The WOOD-PRO project has been supplemented with work from the NORCEL (The NORwegian nanoCELLulose Technology Platform) and the NanoVisc project (Development of high-performance viscosifiers and texture ingredients for industrial applications based on Cellulose Nanofibrils (CNF)), both run at RISE PFI and fully or partly funded by the Research Council of Norway. Different qualities of nanocelluloses have been produced and characterized and samples have been shared with the University of Helsinki for further studies. Doctoral student Ragnhild Aaen (RISE PFI, Norway), employed in the NanoVisc project, made a research visit at the UH laboratory, Finland in order to continue work started during her first visit in 2016. Emulsions stabilized with nanocelluloses and galactoglucomannan and mixtures thereof have been studied.

A project meeting was organized within the American Chemical Society Meeting in San Francisco, 5.4.2017. In addition, a teleconference was organized on 29.11.2017 to plan the joint research work.

**Place and date for the activities:**

5. Activity	Place (country) for the activity	Duration (date)
Research visit by Ragnhild Aaen	UH, Finland	15.1.-17.2.2017
Project meeting	San Francisco, USA	5.4.2017
Teleconference	Skype	29.11.2017

**6. Project status**

- Does the project develop according to the research plan? Please elaborate.
- Does the project deviate from the plan? Please elaborate.

The project is following the research plan and proceeding accordingly. Different nanocelluloses and hemicelluloses are being tested for their functionality in emulsions, gels, and emulgels. Several nanocellulose qualities with different charge density have been produced and characterized. Charged nanocelluloses were able to stabilize oil-in-water emulsions of low oil content at very low concentrations. The combination of nanocelluloses and galactoglucomannans to stabilize emulsions show promising results both for the physical and the oxidative stability of the emulsions. The aim is to develop new advanced uses for forestry-based raw materials by combining efforts from three Nordic research groups. The project produces scientific understanding of the effect of structure, morphology, and purity of nanocelluloses and hemicelluloses on their emulsifying and gel forming capacity that can be used in wide perspective to predict the behavior of different plant-based materials in aqueous and dispersed systems as well as on interfaces. Both scientific and practical knowledge of the range of functional conditions is obtained. With this knowledge, we are able to direct the processes of hemicellulose isolation and nanocellulose manufacturing to yield the best results for the industrial applications. During the last project year, concepts will be provided for novel products applying the best functioning nanocelluloses and hemicelluloses in food (pastes, dressings, beverages, to name a few), pharmaceuticals (emulsions, gels, emulgels), and cosmetics (skin creams, lotions).

**Results during the reporting year:**

7. List the published outputs during the reporting year (peer-reviewed articles, other publications):

1. Lehtonen, M., Merinen, M., Kilpeläinen, P.O., Xu, C., Willför, S.M. Mikkonen, K.S. 2018. Phenolic residues in spruce galactoglucomannans improve stabilization of oil-in-water emulsions. *Journal of Colloid and Interface Science*. 512, 536–547.
2. Ghafar, A., Gurikov, P., Subrahmanyam, R., Parikka, K., Tenkanen, M., Smirnova, I., Mikkonen, K.S. 2017. Mesoporous guar galactomannan based biocomposite aerogels through enzymatic crosslinking. *Composites Part A: Applied Science and Manufacturing*. 94, 93-103.
3. Mikkonen, K.S., Alakalhunmaa, S., Lehtonen, M., Tenkanen, M. Spruce gum – a new natural Nordic stabilizer. *Proceedings of 7th Nordic Wood Biorefinery Conference (NWBC), March 28–30, 2017, Stockholm, Sweden, vol 7, 22-27.*
4. Hassan, E.; Hassan, M.; Abou-zeid, R.; Berglund, L.; Oksman, K. Use of Bacterial Cellulose and Crosslinked Cellulose Nanofibers Membranes for Removal of Oil from Oil-in-Water Emulsions. *Polymers* 2017, 9, 388.
5. Berglund L, Anugwom I, Hedenström M, Aitomäki Y, Mikkola JP, Oksman K. Switchable ionic liquids enable efficient nanofibrillation of wood pulp. *Cellulose* 24 (8) 3265-3279.

8. Other practical outputs during the reporting year (e.g. websites, policy recommendations, conferences, large-scale project applications etc.)

The UH partner established a website, blog, and Twitter account to disseminate the results:

<https://www.helsinki.fi/food-materials-science>

Conference presentations:

1. Mikkonen, K.S., Alakalhunmaa, S., Lehtonen, M., Tenkanen, M. Spruce gum – a new natural Nordic stabilizer. Oral presentation at the 7th Nordic Wood Biorefinery Conference, 28-30 March 2017, Stockholm, Sweden.
2. Mikkonen, K.S., Lehtonen, M., Merger, D., van der Schaaf, U., Kilpeläinen, P., Xu, C., Berton-Carabin, C., Wilhelm, M., Schroën, K. Spruce galactoglucomannans stabilize emulsions against physical breakdown and lipid oxidation. Oral presentation at the 253rd American Chemical Society Meeting, 2–6 April 2017, San Francisco, USA.
3. Mikkonen, K.S., Xu, C., Kilpeläinen, P.O., Lehtonen, M. Novel multifunctional wood-derived emulsifiers. Oral presentation at the Innovations in Food Science and Technology meeting, 10–12 May 2017, Erding, Germany.
4. Bhattarai, M., Kontro, I., Pitkänen, L., Kilpeläinen, P., Lehtonen, M., Mikkonen, K.S. Adsorption of spruce galactoglucomannans (GGM) on emulsion interfaces depends on GGM:oil ratio. Oral presentation at the Gums and Stabilisers for the Food Industry meeting, 27–30 June 2017, Berlin, Germany.
5. Lehtonen, M., Kekäläinen, S., Kilpeläinen, P., Tenkanen, M., Mikkonen, K.S. Hexanal releasing spruce galactoglucomannan aerogels for active packaging of fresh fruit. Oral presentation at the Gums and Stabilisers for the Food Industry meeting, 27–30 June 2017, Berlin, Germany.
6. Mikkonen, K.S., Kilpeläinen, P.O., Lehtonen, M. Wood hemicelluloses act as efficient physical and oxidative emulsion stabilizers. Oral presentation at the 5th EPNOE International Polysaccharide Conference, 22–24 August 2017, Jena, Germany.
7. Lehtonen, M., Kilpeläinen, P., Mikkonen, K.S. Potential food hydrocolloids from the Nordic forests – Wood hemicelluloses as multifunctional emulsion stabilizers. Oral presentation at the 15th Euro Fed Lipid Congress, 27–30 August 2017, Uppsala, Sweden.

8. Berglund L, Jonoobi M, Oksman K. Xylan-lignin based aerogels and hydrogels - effect of crosslinking degree and nanofibre reinforcement. Proceedings of Advancements in Fiber-Polymer Composites Symposium, May 16-18, 2017, Madison, WI USA.



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### Comments to the economic overview:

The project has allocated a large part of costs to the external funds and requests to transfer the remaining budget to the current year's budget.

The other costs covered by the external funding consist of grants to master students, costs of small equipment, and fees for open access publication.

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

Signature of the project coordinator



(Signature)

University of Helsinki

(Institution)

27.2.2018

(Day / Month / Year)

Signature of head of research institution



(Signature)

UNIV. OF HELSINKI

(Institution)

27/2/2018

(Day / Month / Year)

MARINA HEIMONEN, head of the department

(Printed name, function)