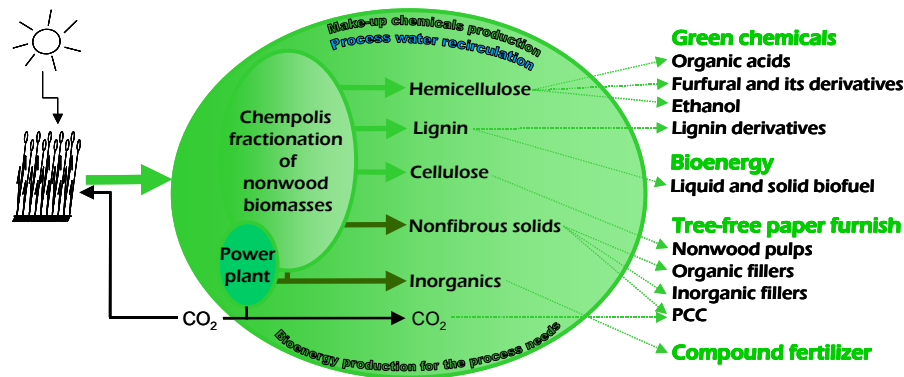


PEGRES:

Paper, bioenergy and green chemicals from nonwood residues by a novel biorefinery



1. Site of research and responsible persons

University of Oulu, Department of Process and Environmental Engineering, Chemical Process Engineering Laboratory, Prof. Juha Tanskanen, *responsible leader of the project*

University of Oulu, Department of Process and Environmental Engineering, Fibre and Particle Engineering Laboratory, Prof. Jouko Niinimäki

Lappeenranta University of Technology, Department of Chemical Technology, Laboratory of Paper Technology, Prof. Kaj Henricson

The research has been performed mainly in these three locations. However, in addition to these sites, national and international research parties, both from academia and industry, will contribute to the project. Furthermore, currently built demonstration plant of Chempolis Ltd in Oulu is able to produce the needed intermediate products for the PEGRES project and thus enabling large scale experimentation.

2. Objectives of the project

The goal of the PEGRES project is to develop a conceptual process model of a sustainable nonwood biorefinery. This pursued biorefinery concept is characterized by (1) total utilization of biomass into selected high value added products, (2) integrated production of paper and papermaking chemicals from the biomass and (3) self-sufficient overall production in terms of energy and process chemicals.

The third character, i.e. self-sufficient production of energy and process chemicals, is obtained by implementing the formic acid nonwood fractionation method of Chempolis Company. The Chempolis platform offers reliable and profitable fractionation of nonwood biomasses to cellulose, hemicellulose and lignin. The two other characters, i.e. production of value added products and paper and papermaking chemicals, would be the research challenges of this project. The target product groups of the biorefinery have been set to be (1) green chemicals from hemicellulose, (2) bioenergy from sulfur free nonwood lignin (3) tree-free paper furnish components from nonwood pulps and nonfibrous solids and (4) compound fertilizers from the inorganics.

3. Research results 2008

3.1. University of Oulu, Chemical Process Engineering laboratory (CPElab)

According to the original project plan, research tasks of CPElab consists of the following areas (1) chemistry studies of hemicellulose conversion (2) conceptual modeling of the biorefinery (3) base case process design and (4) organosolv cooking experiments. Implementing of different tasks from the areas 2, 3 and 4 will continue along the year 2009. Below, it is shortly described the CPElab progress in the PEGRES research during 2008. Research in general has progressed as planned. Only big difference is that the base case process design will be started after the chemistry studies are finished in the middle of year 2009. Following researchers have contributed to the results: Kaisa Lamminpää (CPElab), Laura Kupiainen (CPElab), and Jarkko Karjalainen (UPM, diploma work) and Janne Sandqvist (Chempolis Oy, diploma work). Kaisa Lamminpää has obtained financing from the PEGRES-budget.

Chemistry studies of hemicellulose conversion

The chemistry studies are concentrated on furfural which is obtained from biomass pentosans in acidic conditions. Optimal production of furfural from biomass was planned to be as one important subgoal of the project. Kaisa Lamminpää has concentrated on this task. She has continued the literature study of furfural. The emphasis of this study has been on the kinetics of furfural formation and separation of furfural from reaction media.

Experimental studies on furfural formation and its destruction in acidic conditions have been continued. The goal of the experiments is to create a reliable kinetic model for the biorefinery modeling purposes. Besides furfural formation and destruction in sulphuric acid (continuing from 2007), we have introduced formic acid as a catalyst. According to preliminary studies, formic acid seems to be an effective catalyst for furfural formation and in the beginning of year 2009 we will have more data to compare these two acid catalysts. One scientific article reporting the preliminary xylose-furfural reaction studies has been prepared.

Conceptual modeling of the biorefinery

Commercial ASPEN Plus Engineering software was selected for the conceptual model development environment. Necessary databanks to include properties of the missing components, and properties of the polymers were built. Furthermore, Icarus Process Evaluator will complete the base case design environment, which will be used in the conceptual biorefinery process optimization.

Cooking experiments

Formic acid fractionation of nonwood lignocelluloses by Chempolis process is the key towards a sustainable biorefinery. Chempolis Ltd is acknowledged for their valuable help, knowhow and expertise for conducting necessary cooking experiments and providing the needed intermediate products for the PEGRES project. Especially, produced wheat straw lignin and wheat pulp have been crucial for the two diploma works within the PEGRES project.

3.2 University of Oulu, Fibre and Particle Engineering Laboratory (FPElab)

In 2008 the research of the FPElab was continued according to the updated plan in 2007. The literature study was continued, and the topics were widened for the areas that give new insight for the theme of research. In addition, the information found in 2007 was updated with the latest results.

The lack of suitable analysis methods for the non-wood pulp components were found to be a critical factor in progressing of the research. The lack of reliable analysis method complicates the performance of the fractionation trials. Therefore, the development of new analysis method for the analysis of pulp was started. Test equipment was built and preliminary tests have been started. In addition, the field flow fractionation experiments for non-wood pulp analysis were continued. Negotiations with the industrial partner for co-operation in the development work have been started.

Pressure screen and hydrocyclone fractionations were continued. Trials were made by using hardwood and softwood pulps because non-wood raw material gathering was found to be problematic due to pulp limited production capacity and distant location of production plants. New pilot fractionation equipment was built and trial runs were performed to assure that equipment is suitable for our fractionation purpose.

Mikko Karjalainen performed as a full time PEGRES researcher of FPElab. His studies were planned in a way that gives theoretical background for the solving of the research problem. In addition, background for laboratory experiments and analysis methods were studied. Approximately 70% of his postgraduate studies are completed. Teaching, which includes lectures and student tutoring on bachelor's and master's degrees, has taken approximately 5 - 10% of the annual working time.

3.3 Lappeenranta University of Technology, Laboratory of Paper Technology

Research in LUT differed from the original plan due to maternity leave of the researcher. Therefore the research plan as a whole has been postponed for about 10.5 months. For this reason the research plan have changed from the original plan concerning year 2008. During this reporting period experimental research work has not been done. Instead, two reports have been finished:

- 1) Diploma work which title is: "Evaluation of dewatering of non-wood materials in wet pressing". Based on the results of the work, writing of scientific article is in progress.
- 2) Article which title is: "Nonwood pulp in paper furnish – screening of non-linear effects of variables.