



Environment and Natural Resources Trust Fund (ENRTF)

M.L. 2020 ENRTF Work Plan

Today's Date: 08/12/19

Date of Next Status Update Report: 04/01/21

Date of Work Plan Approval:

Project Completion Date: 06/30/22

Does this submission include an amendment request? No

PROJECT TITLE: Eco-friendly plastics from Cloquet pulp-mill lignin

Project Manager: Simo Sarkanen

Organization: University of Minnesota

College, Department, or Division: College of Food, Agricultural & Natural Resource Sciences,
Department of Bioproducts & Biosystems Engineering

Mailing Address: 2004 Folwell Ave., 203 Kaufert Lab.

City, State, Zip Code: St. Paul, MN 55108

Project Manager Direct Telephone Number: (612) 624-6227

Email Address: sarka001@umn.edu

Web Address:

Location: Central, NW, NE

Total Project Budget: \$193,000

Amount Spent: \$0

Balance: \$193,000

Legal Citation: M.L. 2020, Chp. xx, Sec. xx, Subd. xx

Appropriation Language: This appropriation is subject to Minnesota Statutes, section 116P.10.

PROJECT STATEMENT:

- We will create eco-friendly plastics from the lignin that makes up 25% of the trunks and limbs of northern Minnesota aspen. The lignin will be the co-product generated when aspen wood is pulped using the “kraft” process to form cellulosic fibers for making paper. The closest such industrial process is located in Cloquet (Minnesota) at the Sappi mill, the most modern U.S. pulp mill.
- These eco-friendly lignin plastics will contain higher-than-90% levels of aspen kraft lignin. They will be similar in strength to polystyrene, which is produced from petrochemical sources. Polystyrene is notoriously resistant to biodegradation; it persists in the environment for centuries. In contrast, lignin plastics are eco-friendly: they will undergo complete biodegradation through a process open to total control (simply by adding a little sugar).
- Lignin plastics will increase the profitability of making paper by the traditional method of pulping wood chips. As cellulosic fibers are formed during the kraft pulping process, lignin separates into (so-called) kraft black liquor, from which it is easily isolated. Currently, the value of this kraft lignin is very low because it is burned as a fuel.
- Aspen kraft lignin from Cloquet will be thoroughly washed with water and then air-dried. For comparison, the effect of a simple methylation step will be evaluated. Thus, before and after chemical methylation, the purified kraft lignin will be solution-cast into plastic test pieces. At 10% or lower levels, commercially available blend components will be introduced to bring about changes in strength of these new lignin plastics.
- Economists estimate that the cost of producing lignin plastics is less than half of the polystyrene selling price. As a result, the profitability of making paper with cellulosic fibers from wood chips will increase. Sales of lignin plastics will highlight prospects for profitability in the conversion of other cellulosic residues from agricultural crops and trees to renewable fuels and organic chemicals.

II. OVERALL PROJECT STATUS UPDATES:

First Update April 1, 2021

Second Update October 1, 2021

Third Update April 1, 2022

Final Report between project end (June 30) and August 15, 2022

III. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1 Title: Isolation, purification and characterization of aspen kraft lignin from Cloquet.

Description: Aspen kraft lignin will be isolated by acidifying kraft black liquor from Cloquet. It will be thoroughly washed with water and air-dried. Before and after methylation, the purified aspen kraft lignin will be characterized in regard to its molecular weight distribution by size exclusion chromatography (mwd by SEC), (~~mwd by SEC~~), glass-transition temperature by differential scanning calorimetry (T_g by

DSC), structure by nuclear magnetic resonance spectrometry (NMR), and molecular organization (by X-ray powder diffraction).

ACTIVITY 1 ENRTF BUDGET: \$ 95,294

Outcome	Completion Date
<i>1. Isolate methylated and unmethylated purified aspen kraft lignin for lignin plastics</i>	<i>12/31/20</i>
<i>2. Characterize aspen kraft lignin molecular weight distributions and glass-transition temperatures</i>	<i>03/31/21</i>
<i>3. Characterize aspen kraft lignin structure and molecular organization</i>	<i>06/30/21</i>

Activity 2 Title: Formulations for aspen kraft lignin plastics and their strengths.

Description: Methylated and unmethylated aspen kraft lignin will be cast into plastic test pieces on their own and with commercially available blend components at levels below 10%. These plastics will be characterized with respect to tensile strength (Instron), glass-transition temperature (T_g by DSC) and molecular organization (by X-ray powder diffraction).

ACTIVITY 2 ENRTF BUDGET: \$ 97,706

Outcome	Completion Date
<i>1. Formulations characterized for plastics from unmethylated aspen kraft lignin</i>	<i>12/31/21</i>
<i>2. Formulations characterized for plastics from methylated aspen kraft lignin</i>	<i>03/31/22</i>
<i>3. Tensile strengths of lignin plastics fall between polyethylene and polystyrene</i>	<i>06/30/22</i>

First Update April 1, 2021

Second Update October 1, 2021

Third Update April 1, 2022

Final Report between project end (June 30) and August 15, 2022

IV. DISSEMINATION:

Description: The results will be disseminated through peer-reviewed journals such as *Green Chemistry*, *ACS Sustainable Chemistry and Engineering*, etc. Presentations at regional, national and international conferences also provide excellent opportunities to disseminate project results with scientific communities. Discussions with colleagues at other institutions can provide useful insights into future research directions.

The College of Food Agricultural and Natural Resource Sciences (CFANS) and the Department of Bioproducts and Biosystems Engineering (BBE) at the University of Minnesota have well established

education and outreach programs which are in place and provide valuable opportunities to engage with members of general public. We would also seek to partner with the North Central Sustainable Agriculture Research and Education program that is housed in BBE in producing educational and outreach materials for farmers and stakeholders.

The Minnesota Environment and Natural Resources Trust Fund (ENRTF) will be acknowledged through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications per the [ENRTF Acknowledgement Guidelines](#).

First Update April 1, 2021

Second Update October 1, 2021

Third Update April 1, 2022

Final Report between project end (June 30) and August 15, 2022

V. ADDITIONAL BUDGET INFORMATION:

A. Personnel and Capital Expenditures

Explanation of Capital Expenditures Greater Than \$5,000: N/A

Explanation of Use of Classified Staff: N/A

Total Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation:

Enter Total Estimated Personnel Hours for entire duration of project: 3120	Divide total personnel hours by 2,080 hours in 1 yr = TOTAL FTE: 1.5
----------------------------------------------------------------------------	----------------------------------------------------------------------

Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:

Enter Total Estimated Contract Personnel Hours for entire duration of project: N/A	Divide total contract hours by 2,080 hours in 1 yr = TOTAL FTE: N/A
------------------------------------------------------------------------------------	---------------------------------------------------------------------

VI. PROJECT PARTNERS:

- A. Partners outside of project manager’s organization receiving ENRTF funding: N/A
- B. Partners outside of project manager’s organization NOT receiving ENRTF funding:
 Our only (unpaid) project partner will be Tom Radovich, Paper Production Manager at the Sappi mill in Cloquet, who will supply aspen black liquor for the work. At the present, it would be premature to involve other collaborators because Simo Sarkanen’s group is currently the only one in the world with the expertise necessary to produce lignin plastics containing kraft lignin levels above 90%.

VII. LONG-TERM- IMPLEMENTATION AND FUNDING:

As our LCCMR project nears completion, funds will be sought for an injection-molding apparatus that can produce test pieces under conditions more closely allied to industrial practice. Adequate funding will be requested from the Department of Energy and/or the United States Department of Agriculture. Otherwise, when our work becomes sufficiently far advanced, companies and/or entrepreneurs will be approached for bringing lignin plastics to the market place. Articles can take many forms, ranging from automobile dashboards and computer consoles through stackable auditorium chairs to garden furniture, etc.

VIII. REPORTING REQUIREMENTS:

- Project status update reports will be submitted April 1 and October 1 each year of the project.
- A final report and associated products will be submitted between June 30 and August 15, 2022.

IX. SEE ADDITIONAL WORK PLAN COMPONENTS:

A. Budget Spreadsheet

B. Visual Component or Map

C. Parcel List Spreadsheet – N/A

D. Acquisition, Easements, and Restoration Requirements – N/A

E. Research Addendum – N/A

Attachment A: Project Budget Spreadsheet
 Environment and Natural Resources Trust Fund
 M.L. 2020 Budget Spreadsheet



Legal Citation:

Project Manager: Simo Sarkanen

Project Title: Eco-friendly plastics from Cloquet pulp-mill lignin

Organization: University of Minnesota

Project Budget: \$193,000

Project Length and Completion Date: 2 years - June 30, 2022

Today's Date: 8/12/19

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET		Budget	Amount Spent	Balance
BUDGET ITEM				
Personnel (Wages and Benefits)		\$ 163,000	\$ -	\$ 163,000
1 Researcher 6 (0.75 FTE for 2 years): development of plastics from aspen kraft lignin; 73.5% toward salary, 26.5% toward benefits				
Professional/Technical/Service Contracts				
Equipment repair and maintenance		\$ 2,000		\$ 2,000
Laboratory Services (NMR, X-ray powder diffraction, AFM) for plastic composition optimization		\$ 8,000	\$ -	\$ 8,000
Equipment/Tools/Supplies				
Supplies such as chemical reagents, nitrogen, solvents and laboratory consumables, etc.		\$ 20,000	\$ -	\$ 20,000
Capital Expenditures Over \$5,000				
		\$ -	\$ -	\$ -
Fee Title Acquisition				
		\$ -	\$ -	\$ -
Easement Acquisition				
		\$ -	\$ -	\$ -
Professional Services for Acquisition				
		\$ -	\$ -	\$ -
Printing				
		\$ -	\$ -	\$ -
Travel expenses in Minnesota				
		\$ -	\$ -	\$ -
Other				
		\$ -	\$ -	\$ -
COLUMN TOTAL		\$ 193,000	\$ -	\$ 193,000
SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT				
	Status (secured or pending)	Budget	Spent	Balance
Non-State:		\$ -	\$ -	\$ -
State:		\$ -	\$ -	\$ -
In kind: Unrecovered F&A (54% total project costs)		Secured	\$ 104,000	\$ -
				\$ 104,000
Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS				
	Amount legally obligated but not yet spent	Budget	Spent	Balance
		\$ -	\$ -	\$ -