

Contract No. R-018-028
“Biocomposite Development for Industrial and Consumer Products”

Submitted by c2renew corporation

Principal Investigator: Chad Ulven

PARTICIPANTS

Sponsor	Cost Share
Earth-Kind	\$ 30,000 (cash)
c2renew	<u>\$ 50,000</u> (cash)
Subtotal Cash Cost Share	\$ 80,000 (cash)
Earth-Kind	\$ 20,000 (in-kind)
c2renew	\$ 50,000 (in-kind)
Subtotal In-kind Cost Share	<u>\$ 70,000</u> (in-kind)
North Dakota Industrial Commission	<u>\$150,000</u>
Total Project Cost	\$300,000

Project Schedule – 24 months

Contract Date – July 1, 2013

Start Date – June 1, 2013

Completion Date – June 30, 2015

Project Deliverables:

Status Report: September 30, 2013 ✓

Status Report: December 31, 2013 ✓

Status Report: March 31, 2014

Status Report: June 30, 2014 ✓

Status Report: September 30, 2014 ✓

Status Report: December 31, 2014 ✓

Status Report: March 31, 2015 ✓

Final Report: June 30, 2015 ✓

OBJECTIVE/STATEMENT OF WORK:

This project will develop and trial test biocomposite materials produced by c2renew corporation into consumer products by Earth-Kind and for industrial applications in Bobcat Co., John Deere Co., and Toshiba Corp. products. This project will commercialize technology developed at c2renew.

The project objectives include formulation and trial of a biocomposite formulation for the following products:

- Rodent Repellent Holder, Earth-Kind
- Interior component for a John Deere Co. product
- Inkjet Cartridge, Toshiba Corp.
- Component for a Bobcat Co. product

If successful, this project could help launch a new fast-growing industry and create new jobs for North Dakota. It is anticipated that the project will provide a revenue increase of \$1.7 million per year for c2renew, \$535,500 per year for Earth-Kind, and \$40,000 per year for North Dakota biomass producers.

STATUS:

The contract has been signed and work is underway.

September 30, 2013 Status Report received. It states:

Interim Status Report
September 30, 2013
Dr. Chad Ulven and Michael Ehresmann
c2renew corporation, Colfax, ND 58018
David Lehman
NDSU Manufacturing Extension
Kari Warberg Block
EarthKind

The objective of the project is for continued development and industrial trial of biocomposite materials produced by c2renew corporation for consumer products by Earth-Kind and industrial applications for Bobcat Co., John Deere Co., and Toshiba Corp. c2renew corporation is a recent spin-off small business created in ND from technology developed at NDSU and Earth-Kind is a ND company founded and run by Kari (Warberg) Block (CEO/founder) since 1995 when she began selling potpourris and organic produce on her farm.

In the first quarter of the project we have made good progress toward the planned objectives.

1. The design and prototype of a 100% biocomposite formulation to be used in a new home and industrial rodent repellent holder design for Earth-Kind.
2. Continued development and implementation of biocomposite materials for Bobcat, John Deere and Toshiba prototype parts and applications.

As part of the project, c2renew budgeted for equipment purchases to fulfill work for the EarthKind holder and purchased SolidWorks engineering software and a Dell workstation to run the software. To facilitate the purchase of the equipment NDIC and c2renew structured the project agreement to front load the agreement to cover the equipment purchase. In addition to purchasing the software and workstation as outlined in the below sections we have laid out some key milestones for each of the projects.

The following sections of key milestones reached for each of the objectives being worked on during this project provide more depth to the overall accomplishments reported in this semi-annual status report. Although the milestones are listed by objectives separately, the collaboration between all teams has been seamless from the start of the proposal.

EarthKind

- (5) prototype interactions for EarthKind
- Material development
- Color-matching trials
- Mechanical properties testing
- Early mold design discussions with molder
- Engineered drawings

Bobcat

- Mechanical properties testing
- Ran a second molding trial with molder
- Developed economic analysis on part

Toshiba

- Compounded material for molding trial

- Ran mechanical properties testing

John Deere

- Assess material formulation for part
- Discussion with JD project manager regarding how projects are assessed

December 31, 2013 Status Report received. It states:

**Interim Status Report
December 31, 2013**

In the second quarter of the project we have made good progress toward the planned objectives.

1. Finalized the design and prototype of a 100% biocomposite formulation to be used in a new home and industrial rodent repellent holder design for Earth-Kind.
2. Continued development and implementation of biocomposite materials for Bobcat, John Deere, and Toshiba prototype parts and applications.
3. Development of a new biocomposite material for a new customer.

The following sections of key milestones reached for each of the objectives being worked on during this project provide more depth to the overall accomplishments reported in this interim status report. Although the milestones are listed by objectives separately, the collaboration between all teams has been seamless from the start of the proposal.

Earth-Kind

- Refined engineered drawings for holder to meet Earth-Kind specification
- Analyzed and optimized the components using Finite Element Analysis and mold flow simulation software
- Three additional prototype iterations for EarthKind were completed to optimize the holder design
- Refined color matching to meet EarthKind's color requirements
- In depth work with a molder in order to meet acceptable cost and timeframe requirements for Earth-Kind, as well as optimize part design for molding
- Preparing biocomposite for production of final parts in early 2014

Bobcat

- Additional mechanical property testing of biocomposite formulation was conducted to ensure suitability of material with refined formulation
- A third molding trial of two different formulations of our biocomposite material was run with the injection molder to ensure compatibility of material in part
- Through trialing with Bobcat and the molder, we were able to identify an additional part that can benefit from a biocomposite material rather than a neat polymer resin
- Decisions on further trialing or to go into production will be determined in early 2014

Toshiba

- Performed injection molding trial with large batch of material on single part
- Biocomposite formulation was found to be inadequate for application due to surface appearance
- Identified second part for trialing which does not have a surface finish requirement and will be trialed in early 2014

John Deere

- John Deere reported the results of the testing as performed well mechanically, but surface finish needed improvement
- Formulation being modified to improve surface finish and will be trialed in early 2014
- Preparing for the molding of additional parts which will occur in early 2014

Intelligent Agricultural Solutions

- Intelligent Agricultural Solutions identified as new potential customer for biocomposite formulation
- Compounded and performed mechanical testing on two different biocomposite formulations
- Performed a molding trial for each of the two biocomposite formulations
- One biocomposite formulation met the mechanical and surface quality specifications of the customer
- One formulation met the mechanical specifications of the customer, but did not meet the surface quality specification
- Refinement of the processing will be trialed in early 2014 to meet surface quality specifications

June 30, 2014 Interim Status Report received. It states:

Interim Status Report June 30, 2014

As in the previous reports, the second quarter of the project we have made good progress toward the planned objectives for all projects. As the project launch date approached efforts were primarily focused on the launch date. The official launch date of the project was moved from May to July 1. For the Earth-Kind we focused on the following:

1. Coordinate with tool shop to refine tool for design changes to holder.
2. Produce material for product launch production run.
3. Work with Earth-Kind to map out the production needs during Q4 of 2014 and Q1 of 2015.
4. UV testing on holder to measuring fading and weathering.

In addition to the work being done with Earth-Kind we also continued the development with Bobcat and John Deere. The following work was done with each OEMs:

1. Developed new formulation for Bobcat belt shield.
2. Provided material for new product lines in Bobcat skid steer (i.e. wiring clip, HVAC unit)
3. Molding trial for John Deere X700 Series lawn tractor for PDP (product delivery process) to verify surface quality and finish.

September 30, 2014 interim report received. It states:

Interim Status Report September 30, 2014

In this quarter we focused our efforts on the Toshiba, John Deere and Bobcat items of the project. These were centered on expanding our current work in additional material runs and expansion of project related work. This was accomplished in the following areas:

1. Produced new material for John Deere X700 series lawn tractor.
2. Steinwall (John Deere molder) molded handles. c2renew worked with Steinwall on the molding to ensure production grade parts.
3. Tested handles for John Deere specifications.
4. Worked to find a supplier for material for Toshiba to meet ROHS specifications.
5. Meet with Toshiba molder to discuss plans for c2renew supplying material for toner cartridge and provided a facility tour.
6. Meet with Bobcat to discuss change over in sourcing personnel and how to expand into engineering services with Bobcat.

A majority of our time this quarter was spent working with the OEM and the molder to plan for coming development and how that timeline would be in the quarters and into 2015.

December 31, 2014 Interim Status Report received. It states:

Interim Status Report
December 31, 2014

As in the previous reports, the fourth quarter of the project we have made good progress toward the planned objectives for all projects. In this quarter we focused most of our efforts on Earth-Kind are refining some design components and preparing for Q1 of 2015. Our time was spent in the following areas:

1. Coordinate with molder on part changes to provide more stability in closing mechanism.
2. Produce material for product launch production run (continue to refine the processing parameters).
3. Work with Earth-Kind to map develop new product lines associated with the holder.
4. Coordinate with Earth-Kind Commercialization Manager on 2015 projections.

In focusing our efforts more specifically with Earth-Kind we dug more into how to expand the current design for the holder and provide some more robust details but also how to transition to a second generation holder. From there we developed three design options that would work well for the biocomposite material but also fit the brand aesthetic. From those three options we are now working to move those into further development (much the same as earlier in our grant) and create a new tooling for a 2nd generation design.

In addition to working directly on projects for Earth-Kind we also continued to interface and work with a number of other customers we had met during a trade show we attended in late Q3. Our discussions in Q4 had centered around how to provide a drop in replacement biocomposite for their current product (similar to the John Deere and Toshiba projects).

The March 31, 2015 status report was received. It states:

Interim Status Report
March 31, 2015

Quarter 1 of 2015 was focused across Bobcat, Toshiba, Earth-Kind and sharing the vision of c2renew. We kicked off the quarter by highlighting the work we are doing at c2renew by launching our first product at 1 Million Cups Fargo...a coffee cup made from coffee. We feel it is important to share the message of the work we are doing in ND with waste products.

In addition to advocating for the work we are doing we also meet with Bobcat to discuss c2renew's experience in materials competency and the engineering services we provide. We provided a presentation highlighting the work we did with advanced composites and our current work with biocomposites for Bobcat.

For Toshiba, we've been working to expand to handle the demand of their production. We have been sourcing additional production equipment, space, personnel.

The following are specific tasks tackled during Q1 2015:

1. Share the work of c2renew at 1 Million Cups Fargo and across news outlets.
2. Presented to Bobcat engineers to discuss engineering services.
3. Produced sample material for Toshiba to run sample runs and test the parts.
4. Used FEA to review the potential for 2nd generation Earth-Kind holder.

Moving forward in upcoming quarters we will focus on expanding production to meet the demand. We are planning to be in the expanded facility with new extruder by quarter 3 of 2015. This will allow us to meet the production demand in 2015 and into 2016.

July 8, 2016 - The final report has been received on this project. It states:

Final Report
Dr. Chad Ulven and Michael Ehresmann
c2renew corporation, Colfax, ND 58018
David Lehman
NDSU Manufacturing Extension
Kari Warberg Block
EarthKind

The culmination of the hard work put toward this project has been completed and we couldn't be more pleased with the results. It was a project that resulted in some great outcomes and larger opportunities going forward.

The bulk of our project was focused on our continued work with Earth-Kind to develop a bio-based air freshener holder. Through our work we developed a holder that met the criteria but needed some further refinements which lead to the work we did on the 2nd generation holder. The 2nd generation holder closely matches the form, fit and function that more closely matches the size of Earth-Kinds repellent pouches.

Our work with Earth-Kind on this project and others has led to a great collaborative effort that will continue to bear fruit for years to come with larger distribution of the holder as well as new product launches. The work has resulted in job growth at both Earth-Kind and c2renew as well as facility expansion to continue meeting the needs.

In addition to working with Earth-Kind, c2renew focused on expanding our work with Bobcat and John Deere. With Bobcat we focused our efforts across a couple of opportunities. The first was to introduce our material into a select few product lines. We had good success in moving this through the manufacturing, testing and validation phase however we were slowed a little due to personnel change in the sourcing and reassignment of engineering leads. The second opportunity that we are focusing more on is working more closely with Bobcat on their engineering service needs.

The proposal stated that c2renew would develop a biocomposite containing up to 30wt% agricultural waste filler into its biocomposite formulation for this application. If successful, Bemis will purchase 700,000 lb/yr of c2renew's specially formulated biocomposite to meet their production needs for Bobcat. We have presented to their engineering team and continue to have an open discussion of where we can provide support to the engineering team leads. We were approved by Bobcat and listed on the engineered drawings for this part however we have been working with the molder to get this part into production as there has been turnover in Bobcat sourcing with 3 new people we've had to get up to speed on the material and process.

With John Deere we focused on parts in their turf division and working specifically with their Tier 1 molder in Minnesota to continue our work. During our work we were successful in getting to PDP (product delivery process) which gets our material into the production stream. We will continue to explore other opportunities with John Deere and their molder.

The proposal stated that c2renew will develop a biocomposite containing up to 40wt% agricultural waste filler into its biocomposite formulation for this application. If successful, Melet Plastics will purchase 15,000 lb/yr of formulated biocomposite to meet their production needs for John Deere. We did get another part with Melet for 10,000 lb/yr.

One of the tasks listed in the proposal was a project with Toshiba. c2renew hoped to develop a formulation that not only meets the 25% renewable threshold set by Toshiba but also eliminates the concern of sourcing potentially hazardous materials. It was hoped that Toshiba would purchase 1mil lb/yr of c2renew's specially formulated biocomposite to meet their production. We are continuing our work with Toshiba on this but have not scaled into the 1 million lbs/yr of production. We are currently working on 250,000.

Lastly, one of the other charges of the project was to advocate for building the ND bio-economy and sharing the importance of expanding into bio-based materials. With this work we were able to gain some great visibility and collaborate with a number of new companies; Bogobrush, Appareo, Falcon Plastics, etc. We will continue to advocate for the importance of utilizing bio-based products that provide mechanical, economical and sustainable advantages.

In closing we feel the outcome of the project was successful. Below are few highlights:

- Increase in employee headcount to 8 employees.
- Growth in revenue.
- Growth in customers both in material sales and engineering services. Over the course of the grant we grew our customer base by 15 customers in materials and engineering and indirect by more through our work with 3Dom.
- Continued work with project collaborators.
- Production expansion – larger extruder.
- New 10,000 sq ft. production space planned for 2016 in Colfax, ND.
- Number of pounds of ND biomass utilized – 25 tons.

- The amount of agricultural residuals that we used was lower than originally anticipated however we did branch out into some interesting (i.e. coffee, beer, hemp).

10/31/2016