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March 3, 2011

North Dakota Industrial Commission
Renewable Energy Council
600 East Boulevard Ave Dept 405
Bismarck, ND 58505-0840

RE: Clarification to Address Reviewers' Comments

Dear Renewable Energy Council Members,

Thank you for the opportunity to provide some clarification to address reviewers' comments on our project proposal submitted to the Renewable Energy Program entitled "Biobased Non-isocyanate Urethane Hybrid Resins for Pultrusion Composites". Some of the comments from the reviewers we found to be insightful, while others we feel would have been addressed if more space was allowed in the application package. We strictly adhered to the 15 page, double spacing requirement from the solicitation. Please find these clarifications attached.

In addition, I wanted to bring to your attention a change in the structure of our group. In the original application package, Dr. Zhigang Chen was named the point of contact for the group and was to oversee the new chemistry proposed in the project scope. Within the timeframe that we submitted the proposal until now, Dr. Chen has taken a position with Ashland Chemical Co. and finished his employment at NDSU on March 1st.

Therefore we have restructured as a group to still address all of the objectives originally proposed. I will be taking on the role as point of contact for the group, while Dr. Dean Webster, a Professor in the Coatings and Polymeric Materials Department and a Faculty Associate in the Center for Nanoscale Science and Engineering at NDSU, will oversee the new resin synthesis and characterization proposed in the project.

Prior to joining NDSU in 2001, Dr. Webster spent 17 years in industry at Sherwin-Williams and Eastman Chemical Company. His expertise is in the area of polymer synthesis and crosslinking chemistry for coatings and other high performance applications. He also has experience in resin scale up. He has over 75 peer-reviewed publications, 11 issued patents, and was named the 2011 winner of the Roy W. Tess Award from the American Chemical Society. He has been PI or coPI on numerous research projects including projects on the synthesis of polymers from biobased materials funded by USDA, United Soybean Board and ND Soybean Council. He is an expert in his field and makes a wonderful addition to our group for this proposal.

Regards,

Chad A. Ulven, PhD
Assistant Professor

Clarification to Address Reviewers' Comments
Project Proposal submitted to the Renewable Energy Program
"Biobased Non-isocyanate Urethane Hybrid Resins for Pultrusion Composites"
PIs: Chad Ulven, Dean Webster, Dennis Wiesenborn, & Neena Ravindran

Rating Category 1:
In response to the suggestion of Reviewer 1C, we propose as a group to include a 4th objective for the project: *Feasibility Assessment of the Newly Synthesized Resins Demonstrated*. From the perspective of Tecton Products LLC, an acceptable cost-range for the resins produced from renewables for new biocomposite pultrusions in their company would be in the range of 0.8$/lb to 1.2$/lb and we propose to assess whether the resins developed throughout the project can meet this target by the end of the project.

Rating Category 2:
In an attempt to save space in our proposal, we simplified the proposed new chemistry and therefore did not provide as much detail as the outside reviewers would have liked to see. While the proposed molecular structures are novel, all of the chemistries proposed in each step in the synthesis of the compounds are well known. Some of these synthesis methods are currently being explored in other projects. Thus, the synthesis of the proposed compounds is highly feasible. As indicated in the project plan, the initial stage in the project will be to synthesize candidate compositions based on each of the proposed routes to unsaturated polyurethane hybrid oligomers. Several examples of each resin type will be prepared and characterized for composite properties and then the synthesis method(s) that yield(s) properties closest to the target properties will receive a more focused effort to yield an optimized composition.

The synthesis methods proposed primarily involve polyester formation by transesterification or esterification and are well-known (Odian 2004, Wicks et al. 1999). We have had extensive experience in the synthesis of unsaturated polyesters for UV curing, which are very similar to those used in pultrusions (Ravindran et al. 2006, 2007). Non-isocyanate routes to urethanes are also well-documented. The reaction of a cyclic carbonate with an amine as proposed in Route 1 is highly facile as is transesterification/amidation with an acyclic carbonate (Blank 1990, 1992, Webster 2003). The novelty in these compositions is in combining these methods in order to obtain a biobased urethane-modified reactive resin for pultrusions.

Rating Category 3:
Once a synthesis approach has been identified, then optimization of the properties of the matrix resin system will be carried out. The optimization stage will employ statistical experimental design methods with key variables being molecular weight of the resin, functionality of the resin (number of double bonds/molecule), level of diluent, initiator level, etc. The specific range of the variables to be explored and key properties to be evaluated will be determined jointly by the resin synthesis group (Webster), composite fabrication group (Ulven), and Tecton.

The characterization methods which will be employed to assess physical properties of the newly developed resins and their composites include: viscometry, differential scanning calorimetry (DSC), dynamic mechanical analysis (DMA), thermogravimetric analysis (TGA), tension testing, flexure testing, single fiber pullout testing, interlaminar shear testing, and impact testing.

Some of Tecton's target properties for the pultruded composites produced from the biobased resins proposed include:

- Composite flexural modulus in the range of 1500 to 3000 ksi
- Coefficient of thermal expansion in the range of 4.5 x 10-6 in/in/°F
- Impact strength of 20 in.lb
- Minimal heat deflection temperatures up to 500°F
- Water absorption of less than 5%
- Glass transition temperature in the range of 200 to 280°F

Rating Category 4:
All of the raw materials used in the resin synthesis are commercially available chemicals, with most being commodities, and, thus, low cost. The chemicals for the non-isocyanate routes to urethane groups are expected to be lower in cost than the aliphatic polyisocyanates typically used to make urethanes. Thus, while a detailed cost analysis will be a part of the research program, initial expectations are that the cost will be competitive with currently available resins. Again, the goal for the resins produced from renewables in this project would be in the range of 0.8$/lb to 1.2$/lb.

In response to the job creation comment provided by Reviewer 1C, we plan to outline more clearly how jobs will potentially be created in ND through the development of this resin technology during our presentation time allotted on March 24th in Bismarck.

Rating Category 5:
Again in an attempt to save space in our proposal, we simplified the literature review of related chemistry to that we proposed and therefore did not provide as much detail as the outside reviewers would have liked to see. The synthesis of polymer matrix resins based on vegetable or seed oils has gained significant interest recently and the large number of reviews that have appeared in just the last five years attest to the heightened interest in this topic (Galia et al. 2009, Lu and Larock 2009, Raquez et al. 2010, Xia and Larock 2010).

A number of approaches have been used to create thermosetting resins having reactive unsaturation using vegetable oils such as soybean oil, which could be used as matrix resins for composites. Several methods for derivatizing vegetable oils to introduce reactive double bonds have been explored. One approach involves the synthesis of a monoglyceride of the oil, followed by reaction with maleic anhydride (Can et al. 2001, 2002, Can et al. 2006a, b). Thermosets are then formed by free radical curing of the maleated resin with other diluents such as styrene.

Another approach that has been applied to soybean and other oils has been to first epoxidize the double bonds in the oil, and then react the epoxy groups with unsaturated acids such as acrylic acid to form acrylated epoxidized soybean oil (AESO) (Khot et al. 2001). The epoxy groups of epoxidized soybean oil can be hydrolyzed to the alcohols and reacted with maleic anhydride to form maleated hydroxylated soybean oil (MHSO) (Lu and Wool 2007). To provide a higher crosslink density after curing, additional unsaturated functionality can be provided to AESO resins by reacting the residual hydroxyl groups with maleic anhydride (Lu et al. 2005, Lu and Wool 2007). Methacrylated epoxidized soybean oil resins can be prepared by reacting

epoxidized soybean oil with methacrylic acid, followed by methacrylic anhydride to yield high functionality resins (Adekunle et al. 2010b). The resins had low enough viscosity that the use of styrene as a diluent was not required. Composites from these resins using flax fibers were prepared (Adekunle et al. 2010a).

However, we have not found a report in the literature describing the synthesis of reactive biobased polymers which incorporate urethane groups for use in pultrusions; that again, is why the proposed project is novel to this industry.

Rating Category 6:
Attached are short bios for each of the PIs highlighting their current positions, educational backgrounds, and relevant publications or patents to the proposed project.

Rating Category 7:
In an attempt to save space in our proposal, we simplified the management plan and timetable to exclude subtasks with great detail. As a group, we will use some of our presentation time allotted on March 24th in Bismarck to provide a more detailed plan of tasks and subtasks that we feel are needed to fulfill the proposed objectives.

Rating Category 10:
To be clear, our budget as proposed includes a request from the NDIC for $200,000 with an $80,000 cash match from the ND Soybean Council and $20,000 cash match from Tecton Products Inc. along with an additional $100,000 in-kind match from Tecton Products Inc.; therefore meeting the minimum 50% financial commitment from other sources.

List of References

1. Adekunle K, Aakesson D, Skrifvars M (2010a) "Biobased composites prepared by compression molding with a novel thermoset resin from soybean oil and a natural-fiber reinforcement." J. Appl. Polym. Sci., 116, 1759-1765.
2. Adekunle K, Åkesson D, Skrifvars M (2010b) "Synthesis of reactive soybean oils for use as a biobased thermoset resins in structural natural fiber composites." J. Appl. Polym. Sci., 115, 3137-3145.
3. Blank W J (1990) "Non-isocyanate routes to polyurethanes." Proc. Water-Borne Higher-Solids Coat. Symp., 17th, 279-291.
4. Blank W J (1992) "Novel polyurethane polyols for waterborne and high-solids coatings." Prog. Org. Coat., 20, 235-259.
5. Can E, Kusefoglu S, Wool R P (2001) "Rigid, thermosetting liquid molding resins from renewable resources. I. Synthesis and polymerization of soybean oil monoglyceride maleates." J. Appl. Polym. Sci., 81, 69-77.
6. Can E, Kusefoglu S, Wool R P (2002) "Rigid thermosetting liquid molding resins from renewable resources. II. Copolymers of soybean oil monoglyceride maleates with neopentyl glycol and bisphenol A maleates." J. Appl. Polym. Sci., 83, 972-980.
7. Can E, Wool R P, Kusefoglu S (2006a) "Soybean- and castor-oil-based thermosetting polymers: mechanical properties." J. Appl. Polym. Sci., 102, 1497-1504.
8. Can E, Wool R P, Kusefoglu S (2006b) "Soybean and castor oil based monomers: synthesis and copolymerization with styrene." J. Appl. Polym. Sci., 102, 2433-2447.

9. Galia M, Montero de Espinosa L, Ronda J C, Lligadas G, Cadiz V (2009) "Vegetable oil-based thermosetting polymers." European Journal of Lipid Science and Technology, 112, 87-96.
10. Khot S N, Lascala J J, Can E, Morye S S, Williams G I, Palmese G R, Kusefoglu S H, Wool R P (2001) "Development and application of triglyceride-based polymers and composites." J. Appl. Polym. Sci., 82, 703-723.
11. Lu J, Khot S, Wool R P (2005) "New sheet molding compound resins from soybean oil. I. Synthesis and characterization." Polymer, 46, 71-80.
12. Lu J, Wool R P (2007) "Sheet molding compound resins from soybean oil: thickening behavior and mechanical properties." Polymer Engineering & Science, 47, 1469-1479.
13. Lu Y, Larock R C (2009) "Novel polymeric materials from vegetable oils and vinyl monomers: preparation, properties, and applications." ChemSusChem, 2, 136-147.
14. Odian G. Principles of Polymerization, 4th ed.; Wiley-Interscience: New York, 2004.
15. Raquez J M, Deleglise M, Lacrampe M F, Krawczak P (2010) "Thermosetting (bio)materials derived from renewable resources: A critical review." Prog. Polym. Sci., 35, 487-509.
16. Ravindran N, Vora A, Webster D C (2006) "Effect of polymer composition on performance properties of maleate-vinyl ether donor-acceptor UV-curable systems." JCT Research, 3, 213-219.
17. Ravindran N, Vora A, Webster D C (2007) "Properties of nanocomposites based on maleate-vinyl ether donor-acceptor UV-curable systems." Journal of Applied Polymer Science, 105, 3378-3390.
18. Webster D C (2003) "Cyclic carbonate functional polymers and their applications." Progress in Organic Coatings, 47, 77-86.
19. Wicks Z W, Jones F, N., Pappas S P. Organic Coatings: Science and Technology, 2nd Edition; Wiley: NY, 1999.
20. Xia Y, Larock R C (2010) "Vegetable oil-based polymeric materials: synthesis, properties, and applications." Green Chemistry, 12, 1893-1909.

CHAD ANDREW ULVEN

Assistant Professor, Department of Mechanical Engineering
North Dakota State University, Fargo, ND 58102
Phone: 701-231-5641, Fax: 701-231-8913, e-mail: chad.ulven@ndsu.edu

EDUCATION:

B.S.	Mechanical Engineering, North Dakota State University, Dec. 2001
M.S.	Materials Engineering, University of Alabama at Birmingham, Dec. 2003
Ph.D.	Materials Engineering, University of Alabama at Birmingham, Aug. 2005

EMPLOYMENT HISTORY:

2005 Aug.-present	Assistant Professor, Mechanical Engineering and Applied Mechanics, North Dakota State University, Fargo, ND
2002 Jan.-2005 July	Graduate Research Assistant / Fellow, Materials Engineering, University of Alabama at Birmingham, Birmingham, AL
2002 May-Aug.	Graduate Research Assistant / Fellow, United States Army Research Laboratory, Aberdeen, MD
2000-2001 Dec.	Undergraduate Research Assistant, Mechanical Engineering Department and Agricultural Engineering Department, North Dakota State University, Fargo, ND

RESEARCH INTERESTS:

Biobased Composites Development, Environmentally Friendly Composites Manufacturing, Affordable Manufacturing of Thermoplastic and Thermoset Fiber Reinforced Composites, Composite Process Design and Modeling, Fire Exposure of Polymer Matrix Composites, Nondestructive Evaluation, Low Velocity, High Strain Rate, & Ballistic Characterization of Advanced Materials, Smart Composite Materials Development, Nano-Composites Development

PUBLICATIONS TO-DATE:

4 Book Chapters, 25 Journal Articles, 9 DoD Technical Reports, & 59 Conference Proceedings

PUBLICATIONS RELATED TO PROJECT:

1. Chevali, V.S., **Ulven, C.A.** (2011) Effect of extrusion screw speed on biocomposite thermo-mechanical properties, International Journal of Sustainable Engineering, (iFirst: DOI: 10.1080/19397038.2010.547625).
2. Chevali, V., Fuqua, M.A., Huo, S., **Ulven, C.A.** (2010) Utilization of Agricultural By-products as Fillers and Reinforcements in ABS, SAE International Journal of Materials and Manufacturing, Vol. 3, No. 1, pp. 221-229.
3. Foulk, J.A., Fuqua, M.A., **Ulven, C.A.**, Alcock, M.M. (2010) Flax Fibre Quality and Influence on Interfacial Properties of Composites, International Journal of Sustainable Engineering, Vol. 3, No. 1, pp. 17-24.
4. Mekic, S., **Ulven, C.A.**, Akhatov, I.S., Jerke, E., Kerr-Anderson, E. (2009) Evaluation of In-Plane and Transverse Permeability of Flax Fiber Preforms for Biocomposite Materials, Journal of Biobased Materials and Bioenergy, Vol. 3, No. 2, pp. 156-164.
5. Fuqua, M.A., **Ulven, C.A.** (2008) Characterization of Polypropylene/Corn Fiber Composites with Polypropylene Grafted Maleic Anhydride, Journal of Biobased Materials and Bioenergy, Vol. 2, pp. 258-263.

SYNERGISTIC ACTIVITIES:

1. Active member in the Nurturing American Tribal Undergraduate Research and Education (NATURE) program in North Dakota, hosting summer workshops and coordinating Sunday Academies during the regular school year, June 2007 - present
2. Active mentor a North Dakota Space Grant Fellowship Program Student – Undergraduate Ben Aakre, Sept. 2006 – May 2007; Undergraduate Luke Gibbon, Aug. 2008 – Dec. 2008; and Undergraduate Kate Moser, May 2009 – Dec. 2009
3. Mentored in the North Dakota (ND) Experimental Program to Stimulate Competitive Research (EPSCoR) Advanced Undergraduate Research Awards (AURA) Program Students – Undergraduate Nathan Sailer, May 2006 – Dec. 2006 and Undergraduate Luke Gibbon, May 2007 – Dec. 2007
4. Taught an Expanding Your Horizons Composite Workshop for middle school girls from local and regional middle schools, April 2007
5. Mentored a McNair Scholars Program Research Student – Undergraduate Lori Winkenwader, Jan. 2006 – Dec. 2008

HONORS AND AWARDS:

- NDSU College of Engr. & Arch. 2007-2008 Faculty Researcher of the Year Award
- NDSU Pi Tau Sigma Mechanical Honor Society - Carnot Award for Excellence in Teaching: 2006, 2008

CURRENT / RECENT RESEARCH PROJECTS ($1.4 million as PI):

1. Subcontract from SpaceAge Synthetics from Federal Department of Defense (DoD) Appropriated Funding through the U.S. Navy. *PI*: **Chad A. Ulven**. *Co-PI*: Alan Kallmeyer, Ghodrat Karami, Fardad Azarmi. *Project Title*: Lightweight Composite Solutions for the Spartan SCOUT, an Unmanned Navy Patrol Vessel. *Award Amount*: $812,411, *Period*: 10/07 – 09/11.
2. Composites Innovation Center (CIC), Winnipeg, MB, Canada. *PI*: **Chad A. Ulven**. *Proposal Title*: Investigation of Biobased Foams and Permeability of Natural Fiber Reinforcement. *Award Amount*: $36,118, *Period*: 09/10 – 06/11.
3. North Dakota (ND) Corn Council. *PI*: **Chad A. Ulven**. *Project Title*: Development of Corn Fibers from DDGs for Biocomposite Materials. *Award Amount*: $164,828, *Period*: 07/06 – 06/12.
4. AGCO Corporation. *PI*: **Chad A. Ulven**. *Project Title*: Integration of Composite Materials into Sprayer Boom Design. *Award Amount*: $101,307, *Period*: 05/06 – 12/11.
5. North Dakota (ND) Centers of Excellence / UND SUNRISE. *PI*: **Chad A. Ulven**. *Co-PI*: Dean Webster. *Proposal Title*: Development of Biobased Raw Materials into Composite Materials and Protective Coating Systems. *Award Amount*: $280,000 *Period*: 01/09 – 12/11.

GRADUATE ADVISOR:

M.S. & Ph.D. – Dr. Uday K. Vaidya, University of Alabama at Birmingham (UAB)

ADVISOR:

Currently advising 2 post-doctoral research associates – Dr. Venkata Chevali & Dr. Sait Mekic; 2 Ph.D. students - Michael Fuqua & Shanshan Huo; 8 M.S. students – Derek J. Huotari, Luke Gibbon, Nicholas Goenner, Jessica Lattimer, Loren Soma, Tingting Zhao, Michael Ehresmann, & Sethu Munusamy; 4 undergraduate research assistants – Brent Nerenz, Jeffery Flynn, Benton Bakke, & Ryan Whitacre.

Dean C. Webster

Professor
Department of Coatings and Polymeric Materials
North Dakota State University
PO Box 6050, Dept 2760
Fargo, ND 58108
701-231-8709
dean.webster@ndsu.edu

EDUCATION

Ph.D., Materials Engineering Science, Virginia Polytechnic Institute and State University, 1984.

B. S., Chemistry, Virginia Polytechnic Institute and State University, 1979.

RESEARCH INTERESTS

Synthesis of novel high performance polymers, combinatorial and high through methods in materials science, polymerization reactions, quantitative structure-property relationships, new crosslinking chemistry, kinetics of crosslinking reactions, use of natural products in coatings.

PROFESSIONAL EXPERIENCE

August 2001 to Present

Professor, Department of Coatings and Polymeric Materials, North Dakota State University. Tenured, 2007.

January 1993 to August 2001

Research Associate, Coatings and Resins Research Lab, Chemicals Technology Division, **Eastman Chemical Company**, Kingsport, Tennessee.

August 1984 to December 1992

Senior Scientist, Polymer Research and Development, **Sherwin-Williams Company**, Consumer Division, Chicago, IL.

RECENT PUBLICATIONS

Xiao Pan, Partha Sengupta, Dean C. Webster, "Novel Biobased Epoxy Compounds: Epoxidized Sucrose Esters of Fatty Acids, *Green Chemistry*, in press (2011).

Xiao Pan, Thomas J. Nelson, Dean C. Webster, "Novel biobased dual-cure coating system," *Prog. Org. Coat.*, in press (2011).

Mohammed J. Nasrullah, Ankit Vora, Dean C. Webster, "Block copolymer synthesis via a combination of ATRP and RAFT using click chemistry," *Macromol. Chem. & Phys.* in press (2011).

Samali Datta, Dean C. Webster, "Cationic UV curable conductive composites from exfoliated graphite," *Macromol. Mater. & Engr.*, 296, 70-82 (2010).

Umesh D. Harkal, Aaron J. Muehlberg, Jung Li, James T. Garrett, Dean C. Webster, "The influence of structural modification and composition of glycidyl carbamate (GC) resins on their viscosity and coating performance," *J. Coat. Tech. & Res.*, 7(5) 531-546 (2010).

Zhigang Chen, Bret J. Chisholm, Radhika Patani, Jennifer F. Wu, Shashi Fernando, Katie Jogodzinski, Dean C. Webster, "Soy-based UV curable thiol-ene coatings," *J. Coat. Tech. & Res.*, 7(5) 603-613 (2010).

D. K. Chattopadhyay, Dean C. Webster, "Thermal stability and flame retardancy of polyurethanes," *Progress in Polymer Science*, 34(10), 1068-1133 (2009).

Ankit Vora, Kunal Singh, Dean C. Webster, "A new approach to 3-miktoarm star polymers using a combination of reversible addition-fragmentation chain transfer (RAFT) and ring-opening polymerization (ROP) via "click" chemistry," *Polymer*, 50(13), 2768-2774 (2009).

DENNIS PAUL WIESENBORN
Professor of Agricultural & Biosystems Engineering Department
North Dakota State University (NDSU)

Contact Information

Address: NDSU Dept. 7620, PO Box 6050, Fargo, ND 58108-6050
Phone: (701)-231-7277 Fax: (701)-231-1008 E-Mail: D.Wiesenborn@ndsu.edu

Education

Ph.D., 1989, Rice University, Chemical Engineering (Subspecialty -- Biochemical Engineering).
Bachelor of Science, *Summa Cum Laude,* 1980, Texas A&M University, Chemical Engineering

Previous Employment

Associate Professor, Agricultural & Biosystems Engineering Department and Cereal & Food Sciences Departments, NDSU, 1995-2002; Assistant Professor, 1989-1995
Graduate Research Assistant, Rice University, Houston, TX, 1984-1988
Science and Math Instructor, Lutheran Training Institute, Liberia, West Africa, 1981-1983
Engineer, Synthetic Fuels Section, Radian Corporation, Austin, TX, 1980-81

Research Interests

Extraction and conversion of fats and oils from oilseeds, especially for bio-based polymers and fuel; Troubleshooting technical hurdles in the emerging energy beets and biodiesel industries; Effect of ozone and other antimicrobials on grain handling and storage equipment; Process modeling for biofuels and renewable products; Processing of canola and other oilseed crops.

Teaching Responsibilities

Responsibilities for past four years include ABEN 482/682, Instruments and Measurement, 3 cr, spring, 75% in 2010; ABEN 458/658, Food Process Engineering, 3 cr, fall, even years, 100%; ABEN 263, Biological Materials Processing, 3 sem. cr., spring, beginning 2008, 100% (75% in 2010); ABEN 790 Seminar, 1 cr fall 2010 (100%)

Membership in Professional Societies/Organizations

Southern Regional USDA-CSREES Project S-1007, “The Science and Engineering for a Biobased Industry and Economy,” since 2005, Vice-chair in 2008, Chair in 2009
American Oil Chemists' Society, Associate Editor of *J. of the Am. Oil Chemists' Society* 2002-2007, Publications Steering Committee 2003-2005
Red River Valley Section of American Society of Agricultural Engineers and active participant in North Central Section of ASABE/CSBE
North Central Regional USDA-CSREES Project NC-136/NC-1023, “Improved Thermal Processes for Foods,” North Dakota representative since 1992 and Chair in 1999

Honors and Awards

Fulbright Senior Scholar Award to University College Cork, Ireland, 1997-98; NDSU University Senate, 1996-97, 1999-2001; NDSU College of Engineering & Architecture Outstanding Researcher Award, 1995; National Science Foundation Graduate Fellow, 1985-88; University Fellowship, Rice University Graduate Council, 1984-85; National Merit Scholarship, 1976-80.

Publications in Refereed Scientific Journals (since 2009)

*Lin, H., D.M. Haagenson, D.P. Wiesenborn, S.W. Pryor. 2011. Effect of trace contaminants on cold soak filterability of canola biodiesel. *Fuel*, accepted, DOI: 10.1016/j.fuel.2011.01.029

*Haagenson, DM, and D.P. Wiesenborn. 2011. Impact of North Dakota growing location on canola biodiesel quality. *Journal of the American Oil Chemists Society*, accepted.

Manamperi, W.A.R., S.W. Pryor, K.C. Chang and D.P. Wiesenborn. 2011. Effects of protein separation conditions on the functional and thermal properties of canola protein isolates, *Journal of Food Science*, in press.

*Dhillon, B., D. Wiesenborn, H. Dhillon, and C. Wolf-Hall. 2010. Development and evaluation of a fluidized bed system for wheat grain disinfection, *Journal of Food Science*, 75(6):E372-E378.

*Espinoza-Perez, J.D., C.A. Ulven, and D.P. Wiesenborn. 2010. Epoxidized high-oleic vegetable oils applied to composites, *Transactions of the ASABE*, 53(4):1167-1174.

*Haagenson, D.M., R.L. Brudvik, H. Lin, and D.P. Wiesenborn. 2010. Implementing an *in situ* alkaline transesterification method for canola biodiesel quality screening, *Journal of the American Oil Chemists Society*, 87(11):1351-1358.

*Dhillon, B., D. Wiesenborn, C. Wolf-Hall and F. Manthey. 2009. Evaluation of ozonated water as an antifungal and antimicrobial treatment of durum wheat grain. *Journal of Food Science*, 74(7):396-403.

Doehlert, D.C., D.P. Wiesenborn, M.S. McMullen, J.-B. Ohm, and N.R. Riveland. 2009. Effects of impact dehuller rotor speed on dehulling characteristics of diverse oat genotypes grown in different environments. *Cereal Chemistry*, 86(6):653-660.

*Espinoza-Perez, J.D., D. Haagenson, S.W. Pryor , C.A. Ulven, and D.P. Wiesenborn. 2009. Production and characterization of epoxidized canola oil. *Transactions of the ASABE* 52(4):1289-1297.

*Wilhelmi, A.J., D. P. Wiesenborn, C. R. Gustafson, S. W. Pryor. 2009. Models for fractionation of field peas to supplement corn ethanol, *Applied Engineering in Agriculture*, 25(5):709-717.

* denotes projects for which Wiesenborn was the PI
An additional 41 refereed journal articles were published since 1988.

CURRICULUM VITAE

Neena Ravindran (Ph.D.)
Phone number : (701) 277-5454
Email: NRavindran@tectonproducts.com

EDUCATION

NORTH DAKOTA STATE UNIVERSITY, Fargo, ND (Aug 2001 to Dec 2006)
Coatings and Polymeric Materials, PhD

Research involved investigation of structure-property relationships of UV-curable coatings based on donor acceptor chemistry, for use as a laminating layer in flexible electronics; selected compositions were evaluated for laser ablation properties; hyperbranched polymers and ring-opened polymers synthesized to prepare novel clay organomodifiers for use in nanoclay nanocomposites; the structure-property relationships of the resulting nanocomposites were studied.

WORK EXPERIENCE

TECTON PRODUCTS LLC, FARGO, ND 58108 (July 2010 to current)
R&D PROJECT MANAGER

- Technology feasibility studies for next-generation alternate materials to enhance the properties of the existing range of pultrusion products
- Development and implementation of testing protocols and guides to improve process
- Optimization of formulations

CENTER FOR SURFACE PROTECTION, North Dakota State University, Fargo, ND (March 2007-July 2010)
RESEARCH SCIENTIST

- Preparation and evaluation of coating formulations for improved magnesium-rich primers for use as anti-corrosive primers in aerospace applications
- Continued development of removable coatings for outdoor bronze sculptures
- Development of a UV-curable low-surface energy coating

CENTER FOR NANOSCALE SCIENCE AND ENGINEERING, North Dakota State University, Fargo, ND (March 2006 to March 2007)
RESEARCH ENGINEER

- Survey of flexible battery technology; preparation of prototype flexible battery

ICI INDIA LTD., PAINTS BUSINESS, THANE PAINTS WORKS, INDIA
QUALITY EXECUTIVE (Final designation) (Jun 1996 – Jul 2001)

- Management Representative for ISO 9002: 1994, secured recertification for site. Was the internal auditor for ISO 14001.
- Responsible for technical support to plant, routine laboratory activities for incoming and outgoing materials, customer complaints, training.

ICI INDIA LTD., PAINTS BUSINESS, HYDERABAD PAINTS WORKS, INDIA
APPLICATION RESEARCH AND DEVELOPMENT CHEMIST (Oct 1995 – May 1996)
Developed customer specified shades for factory and retail tinting of latex paints and new product development.

TEACHING EXPERIENCE

COATINGS AND POLYMERIC MATERIALS, North Dakota State University, Fargo, ND
Laboratory courses (as a Graduate Research Assistant)
P&C 485/685 Coatings II Laboratory. Paint Formulation. Spring 2003
P&C 484/684 Coatings I Laboratory. Polymer Synthesis. Fall 2004
Lectures
P&C 473/673 Polymer Synthesis. Introduction to Polymer Synthesis Fall 2007 (2 lectures)
P&C 475/675 Coatings II. Water-borne coatings Spring 2008 (1 lecture)

[A] PUBLICATIONS IN PEER-REVIEWED JOURNALS

1. **Ravindran, N**., Chattopadhyay, D.K., Battocchi, D., Webster, D.C., Bierwagen, G.P., "*Thermal stability of magnesium-rich primers based on glycidyl carbamate resins*" Polymer Degradation and Stability, **(2010)**, 95(7), 1160-1166.
2. **Ravindran**, **N**., Vora, A., Webster, D.C., "*Properties of nanocomposites based on maleate-vinyl ether donor-acceptor UV-curable systems*", J. Appl. Polym. Sci., **(2007)**, 105 (6), 3378-3390.
3. **Ravindran**, **N**., Vora, A., Webster, D.C., "*Effect of polymer composition on performance properties of maleate-vinyl ether donor-acceptor UV–curable systems*," JCT Research, **(2006)**, 3(3), 213-219.

[B] PROFESSIONAL PRESENTATIONS (ORAL/POSTER/CONFERENCE PROCEEDINGS)

1. Richter, N., **Ravindran, N**., "Investigation of binder systems for magnesium rich coatings", Oral presentation at the Advancements in Coatings Series on "Metal Protection through Coatings Technology", Pittsburgh, PA, Oct 19-20, **2010** (Oral)
2. Saville, E., **Ravindran, N**., Webster, D.C., "UV-curable nanocomposite barrier coatings with organically modified montmorillonite for flexible electronic devices" Abstracts of Papers, 239th ACS National Meeting, San Francisco, CA, United States, March 21-25, **2010**, Pages PMSE-274 (Poster; conference proceedings)
3. **Ravindran, N.**, Chattopadhyay, D.K., Battocchi, D., Webster, D.C., Bierwagen, G.P., "Thermal stability of magnesium-rich primers based on glycidyl carbamate resins", paper presented at the FSCT CoatingsTech conference held at Marriott Indianapolis Downtown, Indianapolis, IN, April, **2009** (Oral)
4. Vora, A., **Ravindran, N.**, Singh, K., Webster, D.C., "*Use of PDMS-functionalized Unsaturated Polyester for Preparation of UV-curable Coatings with Modified Surface Properties*" PMSE Preprints (Am. Chem. Soc., Division of Polymer Chemistry) **2008,** 98, 871-872. (Oral; conference proceedings)
5. **Ravindran**, **N**., Chattopadhyay, D., Zakula, A., Battocchi, D., Webster, D.C., Bierwagen, G., "*Properties of Magnesium-rich Primers Based on Silane-modified Glycidyl Carbamate Resins*" International Coatings Exposition Poster Session, Toronto, Canada, October **2007** (Poster)
6. **Ravindran**, **N**., Webster, D.C. "*Effect of Method of In-Situ Synthesis of Hyperbranched Polymer on Properties of Radiation Curable Polymer Clay Nanocomposites*" International Coatings Exposition Poster Session, New Orleans, LA, November **2006** (Poster)
7. **Ravindran, N**., Webster, D.C., "*Effect of in-situ synthesis of precursor oligomers on exfoliation of clay in radiation cured nanocomposites*," Polymer Preprints (American Chemical Society, Division of Polymer Chemistry), **(2005)**, 46(2), 732-733 (Poster; conference proceedings)
8. **Ravindran, N**., Webster, D.C., "*In-situ polymerization of unsaturated polyester in the presence of clay for preparation of exfoliated UV-curable nanocomposites*," Nanotechnology in Coatings: Realizing the Potential, Seattle, WA, June **2005** (Oral)
9. **Ravindran**, **N**., Vora, A., Webster, D.C., "*Properties of nanocomposites based on maleate-vinyl ether donor-acceptor UV-curable systems*" International Coatings Exposition Poster Session, Chicago, IL, October **2004** (Poster)
10. **Ravindran**, **N**., Vora, A., Webster, D.C., "*Effect of polymer composition on performance properties of maleate-vinyl ether donor-acceptor UV–curable systems*," Radtech- UV & EB Technology Expo & Conference, Charlotte, NC, May **2004** (Oral; conference proceedings)

[C] PATENT APPLICATIONS

1. Dean C. Webster, Zhigang Chen and **Neena Ravindran**, PCT international application, "*Radiation curable polymer film having improved laser ablation properties and radiation curable sensitizers therefor*", (2006) WO 2006116032.
2. Gordon P. Bierwagen, Dante Battocchi, **Neena Ravindran**, Neena, Wang, Duhua, PCT international application, "*Methods for improving corrosion resistance of metal substrates"***,** (2007) WO 2007117270.
3. Dean C. Webster, Ankit Vora, **Neena Ravindran**, PCT Application, "*UV-curable low surface energy coatings*", (2008), PCT/US09/34656.
4. **Neena Ravindran**, Dipak Chattopadhyay, Dante Battocchi, Gordon P. Bierwagen, Dean C. Webster, Provisional patent application "*Thermally Stable Magnesium-rich Primers Based on Glycidyl Carbamate Resins*" (Docket No. 016.0011-PR00) USPTO 03/06/10.