PROJECT PLAN PROSPECTUS
QUALITY AND UTILIZATION OF AGRICULTURAL PRODUCTS
NP 306 (100%)
November-December, 2001

Old CRIS Project Number
3620-44000-043-00D

Management Research Unit
3620-50-Biomaterials Processing Research Unit

Location
Peoria, Illinois

Title
Rheological and Interfacial Properties of Bio-Based Materials and Food Products

Investigators
Craig J. Carriere, Lead Scientist.....85%
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Vacant 100%

Scientific Staff Years
2.85

Planned Duration
25 months

Signatures

/s/ Craig J. Carriere	5/08/2001
Research Leader	Date approved
/s/ Peter B. Johnsen	5/16/2001
Laboratory, Center, or Institute Director	Date approved
/s/ Darrel F. Cole	6/08/2001
Area Director	Date approved
/s/ L. F. Flora	6/05/2001
National Program Team Representative	Date approved

Key Words

rheology, viscoelastic, tribology, surface energy, interfacial tension, lubrication

Objectives

Objective 1:

Characterize rheological flow behavior of bio-based complex fluids of potential commercial import to ARS including, but not limited to, Oatrim, Nutrim, Z-trim, and Fantesk™ starch-oil composites.

Objective 2:

Characterize the interfacial properties of biobased mixtures of interest in food and non-food applications as a function of component chemical/physical properties and processing parameters.

Need for Research

Description of Problem to be Solved:

New and expanded markets are needed for annually renewable crops, such as corn and soybeans, because of their continued production in excess of current market needs. New value-added markets are especially needed for starch because of the large surpluses produced annually. In order to cost-effectively produce new bio-based materials for industrial and food applications, an understanding of the effects of processing conditions on the flow and physical properties of the materials needs to be developed.

Relevance to ARS National Program Action Plan:

Plant Biological and Molecular Processes– The search for new processes, uses, and value-added products from under valued agricultural commodities is one of the components of National Program 306. This project will result in technology leading to a broad range of new products from corn and soybeans.

Potential Benefits:

New and expanded markets for cereal grains will reduce Federal outlays for surplus commodity support and will improve the profitability of American agriculture. Multi-billion bushel carryovers of corn each year will provide a vast source of raw material.

Anticipated Products:

Validated models to predict the rheological and interfacial behavior of selected bio-based materials which can be used for design, optimization and quality control.

Customers:

The agricultural community, the general public, metal-working and lubrication companies, the food industry, and the plastics industry. We will work under CRADA's with appropriate companies to transfer the technological products of this research.

Congressional Mandates (Optional):

Not applicable

Scientific Background

The research conducted in this project will have an impact on both CRIS 3620-41000–083-OOD, "Preparation, Properties and Commercial Applications of Starch-Lipid Composites" and 3620-41000–082-00D, "Carbohydrate Compositions with Biological Activities for Increasing Grain Utilization". While these CRIS units are concerned with the production and commercialization of either the TRIM or Fantesk™ products, this CRIS will provide information of direct importance for the optimization of these processes, applicability of potential applications, and quality control. In addition, the models developed for the rheological and interfacial behavior of these materials will aid in the cost-effective scale-up of the production methods for these materials. The efforts of these CRIS units will open new applications for agricultural materials which directly supports National Program 306-Quality and Utilization of Agricultural Products

Approach and Research Procedures

Objective 1:

Characterize rheological flow behavior of bio-based complex fluids of potential commercial import to ARS including, but not limited to, Oatrim, Nutrim, Z-trim, and Fantesk™ starch-oil composites. Evaluate and develop suitable constitutive models for the rheological behavior of the materials at shear rates and conditions encountered during processing. Utilize the models, in concert with computer-aided design, to optimize processing methods and/or develop new more efficient processing schemes.

Hypothesis 1:

Generating rheological models will facilitate development and optimization of processing schemes for transfer of ARS technologies, particularly Oatrim, Nutrim, Z-Trim, and Fantesk™ starch-oil composites.

Experimental Design:

Research will focus on the characterization and evaluation of the rheological behavior of complex bio-based materials. The research will utilize materials that are of current commercial interest to ARS including Oatrim, Nutrim, Z-trim, and Fantesk™ starch-oil composites. The materials will be characterized under shear flow conditions using the resources of the NCAUR rheology research laboratory. Temperature, applied shear rate, concentration, and applied pressure are some of the variables that will be investigated. The exact experiments will be determined based on the processing conditions used for the material and the application for which the material will be used. From the shear rheology data, predictive constitutive models will be developed. The models will be validated over the appropriate shear rate, temperature, and concentration range as required by the applications and by predicting the transient response of the material. If needed, the response in other deformation modes, such as extension, will be conducted with industrial collaborators. Utilization of the models to solve problems of practical import will be sought through close cooperation with CRADA and licensee partners for the materials under investigation.

Contingencies:

If answers to some of the research questions cannot be obtained using the commercial materials, model systems will be prepared and studied.

Collaborations:

Necessary (within *and* external to ARS)– In the event that equipment needed for the studies is not available at NCAUR, universities, or other ARS laboratories will be contacted.

Objective 2:

Characterize the interfacial properties of biobased mixtures of interest in food and non-food applications as a function of component chemical/physical properties and processing parameters. Use results for developing models for predicting interfacial and end-use properties. Knowledge gained will be used for optimizing/accelerating the development of bioproducts of interest to ARS including Fantesk^{TM}-based lubricants and composites.

Hypothesis 2:

Understanding factors controlling interfacial properties of biobased blends and mixtures will improve development of new value-added materials important to ARS.

Experimental Design:

Surface and interfacial energies of mixtures comprising biobased ingredients of interest in ARS commercial products such as Oatrim, Nutrim, Z-trim, and Fantesk^{TM} will be investigated. Binary and ternary mixtures will be characterized as a function of composition, chemical/physical properties, pH, temperature, *etc*. Both miscible and immiscible mixtures comprising liquid/liquid, liquid/solid and solid/solid components will be studied. The exact experimental design will be determined based on the products of interest as well as processing and use conditions. Direct and indirect interfacial characterization methods available at NCAUR will be employed. Certain end-use properties such as friction under boundary and hydrodynamic regimes will also be evaluated. The data will then be used for developing interfacial and end-use property predictive models. Utilization of the models to solve problems of practical importance will be sought through close cooperation with CRADA and licensee partners for the materials under investigation.

Contingencies:

If answers to some of the research questions cannot be obtained using the materials of interest, model systems will be prepared and studied.

Collaborations (external to ARS):

In the event that equipment available at NCAUR is inadequate for the studies, universities, DOE or other ARS laboratories with the appropriate equipment will be contacted.

Conflicts of Interest

See attached sheets (one for each investigator on the proposed project).