FINAL REPORT
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Extrusion & Molding of Animal Coproduct-based Proteins for Geostructural Applications

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***Duration of Project**: 12 months*

Objectives

The primary goal of the proposed research is to utilize various proteins derived from animal byproducts to produce extruded materials for suitable ecofriendly geostructural applications, viz. temporary oil-spill containment/drainage geomembranes. The specific objectives of the proposed research are: (1) Systematic characterization of processability of proteins derived from three different animal sources; and (2) Processing of the proteins into sheets by "melt" extrusion.

Project Overview

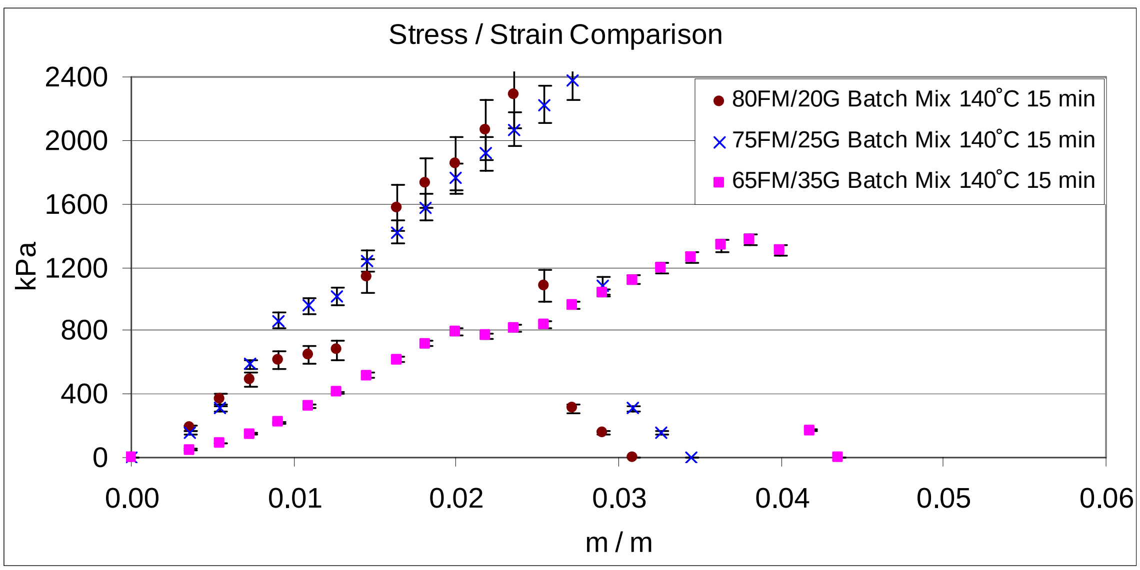
The occurrence of mad-cow disease is mandating that animal waste not be fed back into animal feed. Animal co-products from ruminant sources have been banned in many countries worldwide for use in animal feed. Of the 50 billion pounds of inedible animal tissue by-products (beef, pork and poultry) that are generated annually [NRA, 2005], the rendering of this biomass waste into fat/oil and protein meal fractions leads to the generation of over 4 million metric tons/year of each fraction [US Census Bureau, 2004]). The fat/oil fraction is used as soap, lubricant, feed and fuel ingredients, but the protein meals have been almost exclusively utilized as feed ingredients. Alternative **nonfood** uses for such waste are needed to recover and recycle these waste materials into useful products; otherwise the society would have a tremendous waste disposal problem. The proposed research aims to use such bio-based materials as substitutes for petroleum-based synthetic polymers in environmentally-beneficial, geostructural applications.

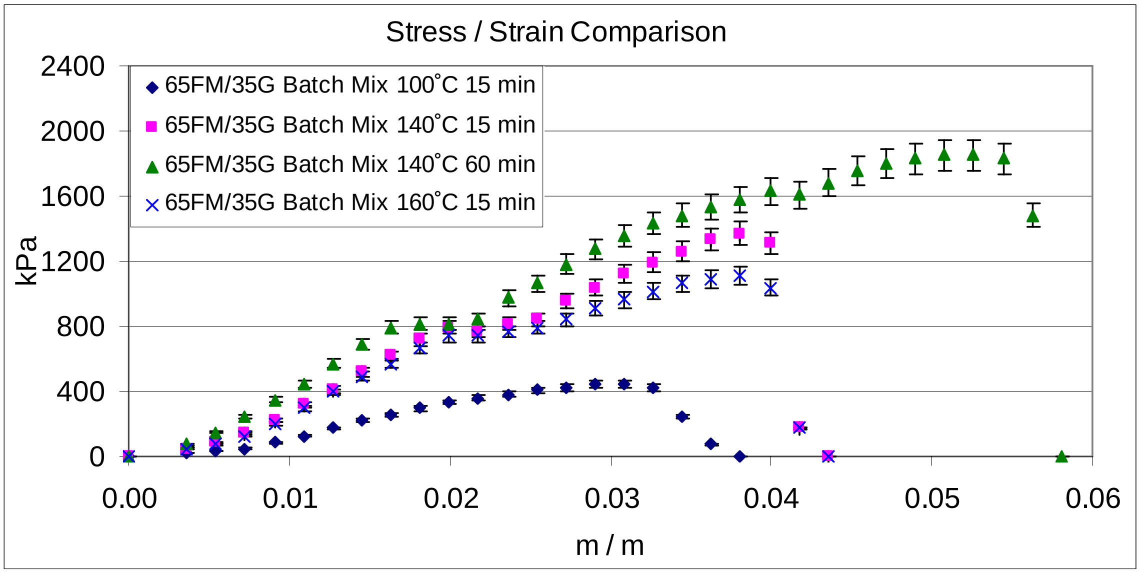
Two techniques were used to mix the feathermeal (FM) protein with a plasticizer, glycerol. In the first technique, a batch mixer, a Rheomix 600 (Haake Inc., Saddlebrook NJ.) having a roller type mixing head was used. The optimum mixing conditions were; a speed of 30 rpm, mixing temperature of 140˚C, and a mixing time of 15 minutes.

In the second technique, a twin screw extruder, Model # MP2015 (AVP Chemical Machinery Inc., Saginaw MI.) was used. The mixture was spoon fed to the extruder at a starving rate. The optimum conditions were a speed of 5 rpm and a temperature of 140˚C. The material processing time was ≈ 11 minutes at the 5rpm speed.

For tensile bars, water vapor permeability discs and water adsorption strips the thermal press sample preparation is identical. Place a 20g sample on an aluminum sheet surrounded by aluminum spacers and topped with an aluminum cover. Since the feather meal contains large inert particles of the quills and other materials, thin films contained holes and were not good for testing. Aluminum spacers were used to create a repeatable sample thickness that did not contain holes. Place this "sandwich" between two steel plates, for support, and insert into press. All samples were pressed at 140±5˚C and 66KN (15,000lbf : approx. 300 psi) for 6 minutes.

Samples were tested in the tensile mode using the procedure outlined in ASTM D638-03 [Standard Test Methods for Tensile Properties of Plastics]. Tensile strips were used for testing, since comparisons to dog-bones produced no measurable difference. A Model # 900 tensile tester and Linseis Model # L-6012-B printer (ATS Applied Test Systems Inc.) were used to perform the testing. Sample lengths of 3cm, 5cm, and 7cm were each tested 3 times using a crosshead speed of 0.254cm/min (0.1 in/min.).





- Protein film strength is highest in an optimum processing temperature of 140°C. If the temperature is too high the material emits stronger odors, is less flexible, and displays reduced strength. If the temperature is too low, the material appears to have less uniformity in color and texture, and possesses reduced strength.
- Flexibility is improved by increased glycerol concentration, increased time exposed to process temperature and shear, and removal of particulates from the protein feed.

Water Vapor Permeability

Water vapor permeability (WVP) samples were tested using methods outlined in ASTM E96-00 [Standard Test Methods for Water Vapor Transmission of Materials]. A Model 506A (Electro-tech Systems Inc.) glove box with automatic temperature and humidity controllers was used to house the samples. A Denver instrument Model # P-603-D balance was placed inside the glove box, to check sample weights without corrupting the environment by opening the glove box. The temperature and humidity were stabilized for 24 hours before testing began. All testing materials were then placed inside the glove box 24 hours before beginning test. Permeability was not greatly affected by glycerol content, processing temperature, or aging of the material.

65/FM/35G batch mixed 100C 15 min, pressed 140C 6 min 15000 lbf

Test 1	1	2	3	4	5
surface area (m^2)	0.0028274	0.0028274	0.0028274	0.0028274	0.0028274
thickness (cm)	0.1383	0.1386	0.1349	0.1443	0.1339
avg Δwt (g/h)	-0.04684	-0.04551	-0.04591	-0.04451	-0.04374
WVP (ng/msPa)	3.48	3.39	3.32	3.45	3.14
ΔR	0.12	0.03	0.03	0.09	0.21
avg WVP (ng/msPa)	3.355				
Avg ΔR	0.10				

Impacts and Significance

The proposed research is directed at the use protein by-products for nonfood applications. Specifically, the extrusion and molding of animal by-product proteins is being investigated to develop geostructural sheets for applications such as reinforcements of temporary roads on soft/weak soils and for oil spill containment. A thick foundation of this protein sheet can help in increasing the load bearing strength of weak subsoils. The layer is permeable to water so that it would not permanently retain a pool of water. The eventual biodegradation of these materials would eliminate the problem of removal of the temporary geomembrane after the excavation is completed.

Future Work:

Studies are planned to develop a more uniform composition of the feed biopolymer protein. Also, an increase in cross-linking of the material will be investigated by adding calcium hydroxide. Although an increase in glycerol content reduced the tensile strength, the flexibility increased with plasticizer content. Therefore, 65/35 composition needs to be investigated thoroughly in future studies.

Acknowledgments:

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