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Peaks & Prairies, LLC

Eco Oil – a Superior – Performance, Bio-Based Motor Oil

Brett Earl

Principal Investigator

406-759-5428 home

406-781-2292 cell

406-759-5018 plant

brett@earlfisherbiofuels.com

Brenda Clark

Business Contact

406-654-1872

admin@peaksandprairies.net

Scientific Report

Executive Summary

Peaks & Prairies' purpose of the research and development project was to create high performance biobased motor oil for both military and consumer use. Our goals for the biobased motor oil included keeping the formulation non-toxic and biodegradable, creating a product that was equivalent or superior to conventional and synthetic motor oils, and maintaining a competitive price point.

Peaks & Prairies, teamed with the USDA, set out to create a superior biobased motor oil using the patented estolide molecule. Lead scientists Dr. Steve Cermak and Dr. Terry Isbell participated in a technology transfer program to teach Peaks & Prairies' Chemical Engineer, Brett Earl, all the intricacies and processes of producing the estolide molecule. In the early phases of the project, Cermak, Isbell, and Earl worked together at the USDA NCAUR laboratory in Peoria, IL, to pinpoint the estolide base stock that would be the most suitable for the development of the biobased motor oil.

After pinpointing the estolide base stock, Earl went on to develop three grades of motor oil, 5W40, 10W30, and 15W40. The 5W40 was his first creation, which turned out to be an excellent learning tool to find additives to improve pour point and oxidative stability. Montana State University-Northern's Advanced Technology Center aided Peaks & Prairies in their research and development by creating a motor oil testing facility. By utilizing MSU-Northern's technology facilities, Peaks & Prairies was able to carry out preliminary testing at a fraction of the independent lab costs, establish benchmarks, and gain confidence prior to engaging in the more expensive certified testing.

By the fall of 2007, Peaks & Prairies was testing a 4 cycle biobased motor oil, 10W30, in a 5.5 horse Honda motor at MSU-N. The preliminary test results were impressive even though the formula still needed some tweaking. At that point, Peaks & Prairies began investigating the procedures to undergo API testing at Southwest Research Institute (SWRI).

In July of 2008, a batch of 10W30 was shipped to SWRI to undergo the IIIG testing protocol, the most severe test of the API battery of tests. The 10W30 passed the weighted piston deposit, average cam-plus-lifter wear, hot stuck rings, and the oil consumption test; however, the formulation did not pass the viscosity increase test. Peaks & Prairies was pleased with the overall performance of the biobased motor oil and is currently modifying the formula.

Earl also formulated a 15W40 to undergo military testing. Currently the viscosity index is being modified to meet military specifications. Once the formula has been modified, a sample will be sent to the U.S. Army's TARDEC facility for testing.

The scientific research conducted by Peaks & Prairies and the USDA aids the world population in leaving a smaller footprint on our ecosystem. Individuals who truly care about being eco-friendly will find our Eco Oil to be competitive in price and recyclable. Any used Eco Oil can be reclaimed and refined as a bar and chain oil. Equally as important, the engine performance of the consumer's vehicles will become better, while harmful emissions will lessen.

Throughout the course of the project, Peaks & Prairies discovered that there are many commercial avenues for the estolide molecule, i.e. cosmetics, inks, textiles, and lubricants. Peaks & Prairies' initial goal is to capture 3% of the synthetic motor oil market in the U.S., which is a feasible goal once our Eco Oil 4 passes the API testing. Our secondary goal is to find a niche for our estolide, other than lubricants,

in the commercial markets. At this point, Peaks & Prairies holds the key to some viable intellectual property. Seeking capital to make our presence in the marketplace is our final move for success.

Actual vs. Goals

Looking back at our original proposal, our first task proved to be successful. Peaks & Prairies utilized the existing estolide technology and built upon it by creating several grades of biobased motor oil. Our second task of completing the CRADA with the U.S. Army TARDEC facility did not progress as we had intended. Meeting the military specifications will take more research, development and testing. Peaks & Prairies' third task was modified due to the fact we could save money by utilizing MSU-Northern's technology facilities to perform preliminary testing on our various motor oil formulations versus the more expensive certified lab at SWRI. The fourth task was executed, but not to the degree that we had hoped. Peaks & Prairies completed the design and layout of a full-scale production plant to manufacture the estolide and biobased motor oil. After designing the production plant, we now know the expense we are likely to incur and the multitude of our vision, however we have not sat down with Montana Manufacturing Extension to gain an expert opinion.

Summary of Research

A chronological summary of the research is outlined below. The two major issues affecting the timeline of the research were; 1) the unsuccessful attempt at finding an additive pour point depressant and 2) the discontinued supply of our original additives package.

Peaks and Prairies was hoping to find a pour point additive to bring our formulation closer to the military specs. We were unable to find such an additive. We changed our focus from a ppm additive to a base oil formulation change. This change in focus caused our bio-based percent to decrease. We could meet the specification but we were no longer greater than 80% bio-based.

When the additives supplier discontinued several of our additives we had to reformulate and retest the product to ensure we would get at or better performance from the new formulation. This change caused us to lose several months of progress.

- 3rd Quarter 2006
 - o Began the technology transfer from the USDA to Peaks and Prairies
 - o Started defining the distillation parameters for the estolide
 - o Started optimizing the recycle stream
- 4th Quarter 2006
 - o Continued the technology transfer
 - o Located a recycle point in the process to limit the waste from the production process
 - o Better defined the distillation temperatures
 - o Began development of the 5W40 gasoline motor oil
 - o Completed a preliminary design for a full-scale production plant
- 1st Quarter 2007
 - o Continued the technology transfer
 - Completed production of the three products; Coco-Oleic estolide, free acid estolide and Oleic estolide

- Trained the Peaks and Prairies Production supervisor on the process
 - Continued development of 5W40 motor oil
 - Completed the oxidative stability development
 - Began the pour point and TBN development
 - Looked at different distillation points and physical properties of the cuts
- 2nd Quarter 2007
 - Continued development of the 5W40
 - Continued looking for a pour point depressant with no luck
 - Continued the research on the TBN additives
- 3rd Quarter 2007
 - Worked with the USDA on distillation equipment transfer
 - Continued researching pour point depressants
 - Began putting a testing protocol together with MSU Northern to run the motor oil in a 5.5 hp Honda motor
- 4th Quarter 2007
 - Began testing the motor on the 5.5 hp Honda motors. The results were favorable.
 - Began work on producing enough product to formulate an API test oil
 - Put the pour point research at a lower priority
- 1st Quarter 2008
 - The second MSU-Northern engine test yielded similar results
 - USDA equipment transfer was completed
 - Our additives supplier discontinued our current package and we needed to reformulated our motor oil
 - USDA completed production of the base estolide for API testing
- 2nd Quarter 2008
 - Completed the reformulation from the additives changed and reproduced our original performance results
 - Distilled the estolide produced and shipped from the USDA
 - Began development of a 15W40 grade gasoline motor oil
- 3rd Quarter 2008
 - Finished the 10W30 formulation for API testing and the results are promising
 - Continued development of the 15W40 motor oil
 - USDA produced another 150 gallons of estolide for distillation
- 4th Quarter 2008
 - Completed the 15W40 motor oil formulation and sent a sample to the USDA for testing

Products Developed and Technology Transfers

Peaks and Prairies developed three grades of motor oil; 5W40, 10W30 and 15W40. All three grades have been through preliminary testing.

Peaks and Prairies completed the technology transfer with the USDA. Peaks and Prairies personnel are able to produce three types of estolide; Coco-Oleic estolide, free acid estolide and Oleic estolide.

