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QUARTERLY PROGRESS REPORT ON
TRIBOPOLYMERIZATION AS AN ANTI-WEAR MECHANISM

for the

Energy-Related Inventions Program

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Submitted by

Dr. Michael J. Furey
Principal Investigator
Department of Mechanical Engineering
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061-0238

for the period

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During the first three months of 1997, progress on the DOE/ERIP project, "Tribopolymerization as an Antiwear Mechanism," was made in several areas. The most important items are discussed below.

1. New Pin-on-Disk Machine Obtained

Acquisition of our new high temperature, liquid/vapor phase pin-on-disk machine described in the Site Visit Handout Material, 23 August 1996. The equipment arrived in early March 1997. A third of its cost came from DOE/ERIP funds designated for this purpose. This device will greatly enhance our capabilities in examining antiwear effects of tribomonomers at high temperatures either under liquid or vapor phase conditions. The machine is instrumented to measure load, speed, temperature, and linear wear with computer-controlled feedback and data acquisition system. It can be used with ceramic as well as metal specimens and is probably one of the most sophisticated and advanced pin-on-disk devices in existence. It was designed specifically for this study by Teretechnology in Radom, Poland with aid from Dr. Furey, Principal Investigator on the DOE/ERIP project. Preliminary checking of the machine and its operation was recently carried out in March.

2. ISATA Paper "Tribopolymerization: An Advanced Lubrication Concept for Automotive Engines and Systems of the Future"

The above paper, accepted for presentation and publication by the 30th International Symposium for the Advancement of Automotive Technology (ISATA), was rated by the reviewers as "excellent." A copy of that paper, which recognizes the part played by our DOE/ERIP grant, is attached for your information. The paper will be presented in June by Dr. Furey.

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3. Thesis Research on DOE/ERIP Project by Mr. Jeff Valentino

Mr. Valentino, who carried out his Master of Science thesis research on the DOE/ERIP Project, continued in the final write-up of his thesis. It has not yet been completed but progress has been made in organizing the extensive data on antiwear effects of "high temperature" tribomonomers, i.e., monomers expected to form protective surface films at high temperatures as well as monomers designed to form more thermally stable polymeric films.

4. Patent Activity

Three new disclosures have been made on patent antiwear compounds and classes of compounds designed for high frictional energy, higher temperature use. At least two patent applications were made during the first quarter of 1997 in areas relating to tribopolymerization as an antiwear mechanism. One of these was on vapor phase lubrication.

5. Future Plans

In connection with our working with Triad Investors Corporation—and more specifically in carrying out more focussed studies of practical applications of our technology for licensing and marketing purposes—we would like to complete our work on the DOE/ERIP project as follows:

- (a) Get the new high temperature pin-on-disk device in operation and conduct tests with ceramic and steel systems at high temperatures (e.g., up to 300°C).
- (b) Examine combinations of monomers designed to act either by different polymerization mechanisms (i.e., condensation vs. addition) or over different temperature ranges.
- (c) Continue to explore the use of new and effective compounds capable of tribopolymerization. Finish FTIRM examinations of all worn surfaces.
- (d) Carry out 2-stroke engine tests using our additives in the presence of additives normally present in 2-stroke lubricants (e.g., detergent-inhibitors). This is important since it is possible that some lubricant additives may interfere with initial adsorption of our monomers on ceramic and metal surfaces prior to polymerization. Interested organizations in our work in this area include the Lubrizol Corporation, a major manufacturer and marketer of fuel/lubricant additives. New engines are available for this study and will be contributed to the DOE/ERIP project at no cost.
- (e) Follow up on previous contacts in designing and testing antiwear monomers for vapor phase applications (e.g., gas fuel injector wear). Some of these are mentioned in the ISATA paper.
- (f) Complete our studies of tribopolymerization for "minimalist" lubrication in machining and metal cutting operations.
- (g) Make appropriate patent disclosures on our significant discoveries. Follow up with new patent applications.

6. A Request

Because the list described under 5 above is ambitious—but certainly important—I (Dr. Furey) request that a no-cost time extension be granted to allow completion of our research during the Summer of 1997. Specifically I would like to request that a no-cost time extension to October 24, 1997—an additional four months—be granted to allow for the greatest benefits from technical, marketing, patenting, and publication standpoints. Dr. Czeslaw Kajdas, my research colleague and co-inventor, will be returning to Virginia Tech this summer. And Dr. Roman Kempinski—who is familiar with the new pin-on-disk machine and who has synthesized useful tribomonomers for our research—will also be available to

work with us during the summer. Drs. Kempinski and Kajdas are also experts at using and interpreting FTIRM surface analysis data. Thus, it is an excellent opportunity to complete the goals described under item 5, particularly since graduate student Valentino will not be available for further research. In addition, another paper on our research has been accepted for the World Tribology Congress to be held in London in September. It is "Models for Ceramic Lubrication at High Loads and Speeds" by M. J. Furey, B. R. Tritt, C. Kajdas, R. Kempinski, and J. Valentino.