TRIBOPOLYMERIZATION AS AN ANTIWEAR MECHANISM

INNOVATIVE LUBRICATION TECHNOLOGY REDUCES WEAR AND FRICTION ON CERAMIC AND METAL SURFACES

Tribopolymerization is an advanced technology that uses molecules, called monomers, to create perpetually renewing films directly on surfaces that require lubrication, such as ceramic or alloy steel. Unlike the action of surface treatments or coatings, which wear away, these protective polymeric films form continuously in critical areas of boundary lubrication and wear. The films efficiently form in localized areas where the greatest amount of wear occurs, reducing wear and friction, and saving energy in the process.

This new technology offers a novel approach to improving lubrication and reducing wear in high-temperature ceramic engines and many other applications. Traditionally, it has been difficult to lubricate ceramic materials due to their different surface characteristics from metal, yet ceramics can operate in corrosive, high temperature environments that often cause damage to metal components. Conventional coating methods offer only short-term lubrication, but Virginia Polytechnic Institute’s tribopolymerization concept results in continuous boundary lubrication over extended periods of time on multiple surfaces.

The tribopolymerization concept has led to the development of new classes of antiwear additives, which reduce friction and wear in ceramic, metal, and advanced alloy applications.

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Project Description

**Goal:** The goal of the project was to carry out studies to demonstrate the merit of the concept of tribopolymerization under more severe conditions of load, speed, and frictional heat generation.

The tribopolymerization concept led to the development of entirely new classes of compounds (additives), which are used at low concentrations in a carrier fluid — lubricant or gas — to reduce wear and surface damage under severe conditions of lubrication. The adsorbed monomer molecules on the solid surfaces polymerize under the conditions of rubbing contact, reacting with themselves to form a polymer chain, which acts as a protective film. This self-replenishing film reduces adhesion and wear on ceramic-on-ceramic, steel-on-steel, and ceramic-on-steel applications. Due to its ability to withstand high temperatures, the invention may serve as an enabling technology in the development of new engines and automotive propulsion systems.

Virginia Polytechnic Institute and State University developed this new technology with the help of a grant funded by the Inventions and Innovation Program through the Department of Energy’s Office of Industrial Technologies.

**Progress and Milestones**

- Several industrial applications for the process have been successfully tested.
- The inventor and his colleagues formed Tribochem International, Ltd., to further promote the technology in various market segments.
- A high-load, high-speed pin-on-disk machine was developed, allowing the development of new classes of monomers designed for higher temperature applications.
- The invention is protected by six U.S. patents.

**Economics and Commercial Potential**

The invention’s market potential is diverse and results from a variety of cost, performance, energy, and environmental advantages. Commercial applications include:

- an ashless antiwear or “lubricity” additive for fuels, including gasoline, diesel, and jet fuel
- the development of ashless lubricants for existing and future automotive engines to reduce environmental emissions
- the lubrication of ceramic engines (such as low-heat rejection diesel engines)
- machining and cutting applications using thin films to reduce friction and ceramic tool wear
- special minimalist pretreatment compositions for assembling and running-in engines
- vapor phase applications to high temperature gaseous systems or to fuel injector wear problems associated with the use of natural gas engines
- use of tribopolymerization as an enabling technology in the development of new engines and propulsion systems.

In some instances, the invention’s market potential depends on the acceptability of ceramics in market segments, such as combustion engines, turbomachinery, and bearings. However, the use of ceramic tools in machining is already established. It is estimated that the market for ceramic wear parts could exceed $500 million in the year 2000.

The invention will have good market potential if it addresses lubrication between ceramic and metal interfaces, which have a market that is expected to grow in the future. These additional markets will likely increase the technology’s value but the initial striking successes with steel systems demonstrate that tribopolymerization has broad applications. Further economic and commercial potential is being explored through the development of a new company, Tribochem International, Ltd., founded by the inventor.