Researchers develop technology for creation of antiwear polymer films

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When Michael Furey, professor of mechanical and biomedical engineering, at Virginia Tech, met Czeslaw Kajdas, then with the Radom Technical University in Poland, at a conference in Europe in 1981, they had differing views on how to form polymer films on surfaces to reduce wear. The result of their eventual collaboration has been fundamental discoveries in surface chemistry and dozens of compounds that reduced wear in metals, advanced alloys, and ceramics.

These include ashless antiwear additives for fuels, such as for diesel, jet, and two-cycle gasoline fuels; lubricants for automotive and industrial applications; and a variety of applications in which environmental concerns are important.

At the 231st American Chemical Society National Meeting in Atlanta on March 26-30, Furey discussed the novel concept of molecular design to create additives and compounds which will reduce wear in liquid and vapor phase applications.

Tribopolymerization, developed by Furey and Kajdas, involves continuous formation of thin polymeric films on rubbing surfaces to reduce wear and surface damage. The films are self-replenishing. Specifically selected small molecules (monomers) adsorb on surfaces. Under the action of sliding contact, thin protective polymer films will form.

Furey first demonstrated the concept more than 30 years ago. At the

1981 conference, Kajdas expressed interest in Furey's idea of surface polymerization. "For condensation-type monomers, I felt that the high surface temperatures produced by friction could initiate polymerization. Kajdas, who was interested in another class of monomers, addition-type, suggested that the emission of low-energy electrons could initiate surface polymerization," Furey recalls. "These were not competing theories, only our ideas as to what was most important for two classes of monomers."

The 1981 military crackdown in Poland sealed off the country and stalled the collaboration, but in 1986, after Kajdas had moved to the Warsaw University of Technology Institute of Chemistry at Plock, he came to Virginia Tech as a visiting professor and then returned every summer. Kajdas' Ph.D. student, Roman Kempinski, also came to Virginia Tech as a Fulbright Scholar. The international team's first research was funded by the U.S. Department of Energy's Energy-Related Inventions Program, and subsequently by the National Science Foundation (NSF).

"As a result of this research, we have reached a better understanding of the fundamental process of tribopolymerization, including the action of low- energy electrons emitted from rubbing surfaces," said Furey. "With NSF funding, we were able to design, build, and use an advanced system for measuring such particles (a Ph.D. thesis by Gus Molina)."

Another result was several effective additives for reducing wear with metals, alloys, and ceramics in both liquid and vapor phase applications. These ashless compounds find uses in an enormous variety of applications. One example is a minimalist pretreatment for small engines. Putting oil in engines to test them at the factory, even when most of the oil is removed afterwards, costs thousands of dollars. Furey and Kajdas developed a lubricant that replaces 500 grams of oil with 5 grams of lubricant. It also saves the time of filling and emptying the engines with oil.

"Molecular design is a powerful approach that does not rely on the usual trial-and-error," Furey said.

Furey and Kajdas' collaboration has resulted in many publications, presentations at scientific meetings in 12 countries, a number of Ph.D. dissertations and master's degree theses, six patents, and the company, Tribochem International Ltd., doing business in Blacksburg, Va., and Poland. Tribochem, the Institute for Terotechnology in Radom, Poland, and the Central Laboratory of Petroleum in Warsaw recently agreed to collaborate to move the discoveries and knowledge into practical and industrial applications.

Source: Virginia Tech

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