The 8th Green and Sustainable Chemistry Award Awarded by the Minister of the Environment

Takashi Saeki

Dept. of Applied Chemistry and Chemical Engineering Yamaguchi University

Keiji Tokuhara

Shunan Region Local Industry Promotion Center Foundation

Toshio Matsumura

ESP Cooperative Society

"Development and Spread of Energy Saving Technology by Using Drag-reducing Additives"

A new class of energy-saving drag-reducing additives has been developed and deployed that markedly reduces the pumping power for fluid transport in air conditioners and other water closed-loop HVAC equipment. The technology has been adopted at over 120 sites throughout Japan and has been shown to reduce the energy consumption of pumps by 20-50%. It is estimated that if the technology were applied to the HVAC systems in all business buildings throughout Japan, CO_2 emissions could be slashed by as much as 500,000 tons a year. So far the technology has been investigated primarily at the academic level, but wider dissemination of the technology through cooperation between business, universities, and government could bring enormous energy-saving benefits, and contribute to the goals of green sustainable chemistry (GSC).

This initiative was launched as a collaborative project between the Shunan Regional Local Industry Promotion Center and the LSP Cooperative Society (made up of three small-to-medium-sized companies in the Shunan district of Yamaguchi Prefecture) based on starter seed technology developed at Yamaguchi University. Reduction in drag flow compared to a Newtonian fluid is called the drag-reduction effect, and it's well known that certain polymer solutions and surfactant aqueous solutions exhibit this effect. Among these, surfactant systems show particular promise for use with closed-loop HVAC systems because they form aggregates of rod-like micelles that suppress flow turbulence, and even when these micelles structures are broken up by the shear force of pumps and other equipment, they are immediately reconstituted.

In the presence of counter-ions (salicylic acid derivative), we found that quaternary ammonium salt cationic surfactants stably exhibited the drag-reduction effect over a wide range of temperatures, and we conducted field trials—the first in Japan—using this compound in HVAC equipment 1994. Based on the results of these trials, we successfully obtained patents for our basic intellectual property pertaining to cationic surfactants exhibiting drag-reducing effects, as well as for the energy-saving use of surfactants to reduce drag in fluid transport.

We developed a drag-reducing additive product called LSP-01 that is tailored for use in air conditioners and other closed-loop HVAC systems. LSP-01 was an innovative breakthrough water treatment chemical product that saves substantial energy. We followed up with the development of a range of OEM and other similar products based on our basic intellectual property.

We addressed many issues as the drag-reducing technology continued to spread—we developed methods for determining the optimum additive and how to apply and manage the additive for actual equipment systems that are much like black boxes filled with instrumentation, we investigated the effects that surfactants have on the environment, and so on. In the process of dealing with these issues, we developed a substantial body of expertise that has supported further penetration of the technology. By the second half of 2008, equipment using the drag-reducing technology could be found at over 120 sites across Japan including general businesses, retail stores, hospitals, factories, high-rise buildings, theme parks, and airports, and the energy consumed by pumps at these sites was substantially slashed by 20 to 50%. Meanwhile, we have sought to raise awareness about the technology by participating in various exhibitions and seminars, and taking every opportunity to give presentations about the technology. We are currently working to apply the technology to all kinds of plant equipment and not just HVAC systems, so the drag-reducing technology will be applied to a far greater range of applications in the years ahead. There is also enormous potential for application of this approach to other fluids besides water, so we can expect a lot of research in this area.

Finally, we observed certain characteristic near-wall momentum and heat transfer behavior in flows that calls for further investigation. The behavior is attributed to the effects of uneven transfer phenomena of micelle motion in pipes for drag-reducing flows, and investigation of this phenomenon should lead to new insights regarding the mechanism involved in drag-reducing flows.