MOLDING A NEW METALWORKING FLUID

Photo: ueaphan - Fotolia

By Mary Moon

Gelatin, the substance responsible for everyone's favorite jiggly dessert, is breaking the mold for metalworking fluid formulations. This novel additive can improve antiwear and cooling performance of finished lubricants, in addition to other benefits.

Gelatin is a mixture of molecules that are soluble in hot water and associate to form a solid at lower temperatures, depending upon concentration. In addition to molded desserts, gelatin is used in gummy bears, marshmallows, yogurts, ice creams, aspics, sausages and a plethora of other products.

A specific form of this everyday substance, hydrolyzed gelatin, shows promise as an additive for metalworking fluids, said Lara Niemann, marketing director at Gelita USA. Headquartered in Eberbach, Germany, the Gelita Group is a leading global producer of gelatin and other collagen proteins for food, health, nutrition and pharmaceutical applications.

Gelatin is obtained from collagen, the main structural protein in the bodies of humans and other animals. Collagen proteins are long, chain-like molecules composed of amino acids. A single collagen molecule consists of three amino acid chains twisted together to form a helix, resembling a spring or a piece of yarn. In animals, these molecules pack together and form microscopic fibers onto which cells and minerals deposit to form muscles, skin, bones, teeth and many organs.

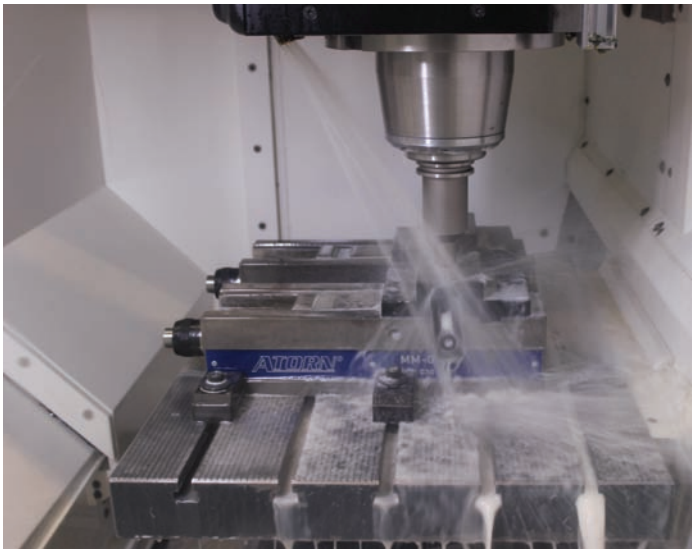
Gelita operates one of the world's largest gelatin factories in Sergeant Bluff, Iowa. Collagen is obtained from the bones, hides and connective tissue of cows and pigs. These sources are treated to break down the structure of collagen fibers and remove fat, minerals and other substances. The collagen then undergoes hydrolysis, in which reactions with water break certain bonds between amino acids to decrease the molecular weight of the protein molecules. The proteins are then extracted and purified into a highly concentrated fluid called a liquor. Additional steps convert this liquor to gelatin powder.

For Novotec CL800, Gelita's metalworking fluid additive, the proteins are further processed with specific enzymatic hydrolysis reactions followed by filtration, evaporation and sterilization. The result is a highly concentrated liquid of hydrolyzed collagen that is completely soluble at any concentration in water.

The company recently patented the Novotec family of protein products, intended as a new class of performance additives for metalworking fluids, cleaning agents and detergents, Neimann said. These proteins contain certain

chemical groups that adhere to hydrophobic (water repellent) surfaces, as well as other chemical groups that attract water molecules. As a result, the proteins form hydrophilic (water attracting) films of hydrated molecules on various surfaces.

The CL800 protein, which has been used in field trials in Germany for nearly two years, was developed as an additive for water-miscible metalworking fluids. Supplied as a liquid concentrate of approximately 50 percent specific protein in water, along with trace levels of citric acid and potassium sorbate as antioxidants, the company claims the shelf life of unopened containers is 12 months from the date of manufacture.



Hakuform A805, formulated with hydrolyzed gelatin, was tested in a CNC machine during a field trial at Heidelberger Druckmaschinen. (Photo: Gelita)

Test cylinders after Reichert Abrasive Wear Test using (left to right) water, 5 percent solution of a commercially available cooling lubricant, and 5 percent solution of Novotec CL800. (Photo: Gelita)

TESTING THE WATERS

Eric Yezdimer, research and business development manager at Gelita, and his colleague Melissa Simon, director of sales, explained that the protein molecules in their product adsorb on carbon and stainless steels, aluminum alloys and other metals. Typical semi-synthetic and synthetic metalworking fluids are formulated from emulsified oils and polymers such as polyglycols, respectively, in water. The hydrophobic effect drives these oils and polymers to adsorb on metal surfaces of workpieces and tools, where they reduce metal-to-metal contact and friction during metalworking operations.

Using the Reichert Abrasion Wear Test, Gelita compared its additive with commercially available mineral oil based and water based metalworking fluids. A lubricated ring was oriented cross-wise against a test cylinder, both made of 100Cr6 bearing steel, under an applied load of 350 Newtons and rotated at 1.7 meters per second (960 rotations per minute) for a travel distance of 100 meters, or one minute. The size of the wear scar on the cylinder corresponds to the antiwear performance of the lubricant. The company reported that solutions of 6 to 10 percent weight per weight diluted Novotec CL800, without any other substances in the solution, outperformed fully formulated products.

In water-miscible coolants, water is more than a solvent for emulsified oil or polymeric lubricants; it is the primary means of carrying heat away from workpieces and tools. This cooling effect is particularly important because heat causes oils, polymers and additives such as corrosion inhibitors to undergo oxidation reactions and lose their effectiveness.

Formulating traditional oils and polymers in water-miscible metalworking fluids improves lubricity but interferes with cooling. Thermal conductivity of water is several times greater than oils. Adsorbed oils and polymers separate metal surfaces from water and interfere with heat transfer during metalworking operations.

Niemann, Simon and Yezdimer assert that Gelita's product combines the best features of emulsified oils or polymers and water: efficient lubrication and cooling. Polar amino acids help the protein molecules adsorb on metal surfaces where they form films and provide lubricity. Water molecules associated with adsorbed molecules help transport heat and cool hot parts and tools.

To study heat transfer, the company collaborated with an academic laboratory at Theodor-Frey-Schule in Eberbach. A metalworking lathe was used to machine AlSi12 aluminum alloy pistons. After machining at relatively high speeds, piston surfaces that were lubricated with 2 percent Novotec CL800 solution appeared comparable to those that were lubricated with a fully formu-

lated, 5 percent mineral oil emulsion used for the regular machining of these pistons—there were no visible residues of oxidation byproducts or metal debris.

Using the mineral oil emulsion at slower speeds, residues welded to surfaces; this did not happen with the protein solution. These observations support Gelita's claim that water-miscible metalworking fluids formulated with this material can cool more effectively than those formulated with oil.

Yezdimer explained that worked pieces and chips tend to carry out much less Novotec CL800 than oils and other polymers because the product is more water soluble. Less carryout results in less consumption of the lubricant, leading to reduced costs and waste. This means metalworking shops using formulations with the protein additive can decrease additional expenses and chemical waste associated with cleaning parts before they are welded, phosphated, painted or otherwise processed.

However, Yezdimer stressed that using effective rust or corrosion inhibitors is mandatory for metalworking fluids containing his company's product, because such clean metal surfaces are naturally subject to corrosion in the presence of water and air.

Chemical company Lanxess' Lubricant Additives segment worked with Gelita to develop a guideline metalworking fluid formulation. The pH 9 fluid is based on water and includes 25 percent Novotec CL800 along with ten other ingredients. Gelita reported that 10 percent of their guideline formulation in deionized water gave a 15-square-millimeter wear scar in the Reichert test. The company suggested diluting this formula to between 9 and 16 percent for tapping or drawing and 5 to 8 percent for drilling, grinding, milling or cutting.

ANTS AT THE PICNIC?

Since protein is a natural food source for many life-forms, formulators may be concerned about the potential for microbial contamination. Yezdimer explained that many of the diverse types of bacteria and fungi typically present in end-use diluted metalworking fluids can metabolize proteins like hydrolyzed gelatin, though proteins are not unique in that regard. While these bugs require additional nutrients in order to grow and thrive, such nutrients are invariably provided by both the make-up water chemistry and other metalworking formulation components.

Any complete metalworking fluid formula may require additional stabilization against microbial growth and corrosion, Yezdimer continued, depending on its work environment. He advised against using formaldehyde-releasing biocides because Novotec CL800 will effectively deactivate them. Instead, he recommended other broad-spectrum biocides such as benzisothiazolin-3-one (BIT) or methylisothiazolin-3-one (MIT), although none of the isothiazolin-3-one biocides work in as broad a range of formulations as many of the formaldehyde condensates.

Consultant and microbial control expert Fred Passman, president of BCA Inc. in Princeton, New Jersey, explained to *Lubes'n'Greases* that a combination of bioresistance laboratory tests and long-term field trials will be needed to evaluate how Novotec CL800 actually affects finished metalworking fluid bioresistance.

Nevertheless, successful field trials indicate that formulators have already found ways to produce stable protein based formulations without formaldehyde. Chemische Werke Kluthe GmbH, headquartered in Heidelberg, Germany, developed its own formulations including Novotec CL800 for commercially available metalworking fluids: Hakuform A803 and Hakuform A805. Gelita reported results from two field trials using these fluids.

THE PROOF IS IN THE PUDDING

The first field trial, at G+F Sondermaschinen in Beerfelden, Germany, included turning, milling and tapping various chromium-nickel alloys, steels and aluminum alloys. After a full year of use in a computer numerical control machining center and in a band saw, G+F reported that the formulation improved the quality of machined surfaces, especially nonferrous metals; increased the service life of saw blades; reduced foaming and eliminated residues.

In addition, operators at G+F with known allergies to conventional metalworking fluids did not report having skin or other allergic reactions to fluids formulated with Gelita's protein.

The second field trial took place at Heidelberger Druckmaschinen AG. Approximately 100 trainees used conventional turning, milling, drilling and grinding machines and CNC machines to process ferrous and nonferrous alloys as well as composites. During the trial, the company reported decreased lubricant consumption, fewer equipment maintenance issues, easier cleaning of machines and tools, and other advantages.

"Our focus was on lifetime of tools and skin compatibility. We are very satisfied with the results," said Christian Beck, head of the training center for technical professions at Heidelberger Druckmaschinen. "Compared to earlier times, where skin irritation was definitely an issue sometimes, we could not find a single case of skin intolerance on one of our trainees. There were also no odors. In addition, the new cooling lubricant is very stable and needs less maintenance." ▮

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