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Monitoring programs and biocide use for maximizing lubricant system performance are suggested based on an explanation of the contribution of microbes to lubricant degradation.

Biocides for lubricant rancidity and biofouling prevention

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INDUSTRIAL lubricants are increasingly providing a rich environment for microbial growth and proliferation. Most of the knowledge of lubricant biodeterioration has been extrapolated from field and laboratory experience with metalworking fluids. Compositionally more complex than most lubricants, metalworking fluids are either solutions or emulsions of 5 to 10% coolant concentrate in water. The fatty acids, sulfurized oils, glycols and other organic components of metalworking fluids and other lubricants provide a rich food source for microbes. Coolant recirculation provides aeration to support aerobic microbial activity. Most lubrication systems do not share this characteristic with metalworking fluid systems. Lubricant flow tends to be slower and absorbs less entrained air. Recirculating systems provide an ideal environment for biofilms to grow. Large systems may have several square miles of surface area for oxygen to be exposed to lubricant. Except for fire retardant hydraulic fluids, with their high water content, moisture enters the system through condensation.

Microbes are most prevalent on system surfaces where condensation co-mingles with lubricant to support development. The microbes inhabiting the biofilms that form on these surfaces act like fixed-film biological reactors; drawing nutrients from the coolant and excreting waste products back into the stream. The net effect is lubricant biodeterioration.

The objective of contamination control is primarily to prevent biodeterioration. A secondary, but often consequential objective is to minimize biomass accumulation. Properly used as part of an overall lubricant management strategy, biocides play a major role in inhibiting both biodeterioration and biomass accumulation.

Biocides

Biocides may be used as preservatives or disinfectants. When used as preservatives, biocides are added to uncontaminated fluids to prevent microbes from proliferating.

Lubricants are typically formulated water-free (except for high water-content specialty lubricants). However, the term water-free is relative. A lubricant containing 0.2% water has 2 gal of water for every 1000 gal of product. This may appear insignificant, but relatively simple calculations reveal a different perspective. A moderate microbial load in lubricant-associated water is 10,000 bacteria/millilitre. One gallon contains 3.78×10^3 millilitres. Thus, 2 gal of water in a 1000-gal system contains approximately 1×10^7 bacteria.

Any contamination introduced during blending or drumming can proliferate in-drum during storage. Although coolant concentrates rarely turn rancid in-drum, unpreserved concentrate can be a significant contamination vector for metalworking fluid systems. Used as in-drum preservatives, biocides prevent coolant concentrates from contributing to microbial loads in metalworking systems.

At the customer's site, biocides are used to maintain a check on spoilage microbes. In this situation, the biocide's role is not to achieve sterility. The objective is to control biodeterioration. Alternative strategies for achieving contamination control will be discussed subsequently.

Lubricant biodeterioration

The objective of this article is, primarily, biocides, not microbial activity in lubricants. However, an understanding of microbes forms a basis for making informed decisions regarding biocide selection or use strategies.

Lubricant rancidity is relatively rare compared with metalworking fluid rancidity. However, as refinery operations have evolved to meet increasingly stringent clean air act regulations, the chemistry of lubricant base-stocks has shifted toward lower aromatic and higher paraffinic organic compound contents. Consequently, it is more biodegradable (not necessarily a disadvantage if the concern is waste treatment).

In lubricant systems, microbes exist in a relatively steady state, operating as consortia, unless disturbed. In a consortium, the overall effect of the microbial community is greater than the sum of the activities of its individual members. Some species secrete biosurfactants that trap hydrocarbons into small micelles, or invert emulsion oil in water droplets. Species that can attack base-stock or other lubricant components secrete metabolic wastes that other microbes can use as food. This microbial food chain has the net effect of accelerating biodeterioration. Microbial activity is a continuous process. Microbes excrete low molecular weight (C1 to C4) fatty acids, mercaptols, skatols and other volatile, organoleptic molecules (Fig. 1). Microbes are continuously active, even if there is only an occassional awareness of their symptoms.

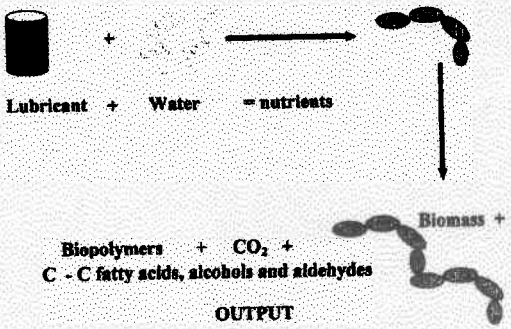

Fig. 1 — Bioconversion of lubrication constituents into new biomass: carbon dioxide; low molecular weight organic molecules (odorous); and biopolymers (biofilm/slime).