Factors Affecting Selection of Metalworking Fluid Biocides

by Dr. Harold W. Rossmore
Bionan Laboratories, Inc.
Warren, Michigan

and

Leonard A. Rossmore
Bionan Laboratories, Inc.
Warren, Michigan

Ever since water became an essential component of metalworking fluids (MWFs), some 60 years ago, microorganisms have been a problem necessitating their control. Many strategies have been offered to prevent microbial deterioration. These include bioreactive fluids, good housekeeping, and biocidal agents, both physical and chemical. Undoubtedly all of these contribute to fluid longevity. However, large central systems (XS of 25,000 L) with long residence times cannot be controlled indefinitely with good housekeeping or so-called bioreactive fluids. Thus, additives specifically aimed at controlling microbial growth became part of MWF formulas or part of the tankside additions during use.

POLITICAL

During the past 60 years, the selection of biocides has been determined by an ever-increasing number of factors. At the beginning, little or no restrictions were applicable and the only consideration in selection was, was it effective? There were no concerns of either occupational hazard or environmental impact. In the USA, the Clean Water Act (U.S. EPA, 1970) imposed point discharge standards for a large number of organic and inorganic potential toxicants. This list included severe restrictions on phenol and derivatives, limited to 50 ppm in discharge. Unfortunately, this was translated into "these wastewater regulations dramatically discouraged the use of phenols or phenol derivatives." This was a misplaced fear since law had no bearing on the actual application since after use, oil recovery and dilution by other sanitary waste the phenol was no longer an effluent problem. However, in 1972 the Pesticide Act became law in the USA. This law mandated that industrial biocides were economic poisons and must be registered as such with the Environmental Protection Agency (EPA). This meant that toxicological testing (at least acute) and effects on least two environmental vertebrate species, a fish and a bird, and demonstrated efficacy in the industrial substrate against a collection of appropriate microorganisms. In this legislation, the USA at that time was unique. The process, however, limited the introduction of new chemistry in the USA. Eventual efficacy requirements for all non-public health related biocides, including those for MWF, were dropped. The EPA had concluded that the marketplace should decide efficacy. Now a political decision made it possible for marketing to play a role in the successful promotion of a biocide. Without a legal requirement for efficacy testing, selection of biocides is often based on what the manufacturer of that biocide claims. An alternative is to rely on third party efficacy testing more closely related to the individual needs of the consumer. This aspect will be discussed in more detail in a later section.

In 1987 the U.S. EPA added a requirement for chronic toxicity testing for biocides, the extent depending on the category of exposure. Of three categories - low, medium, and high - metalworking biocides were placed in the latter, meaning the most extensive battery of tests were presented.


Journal of the Society of Tribologists and Lubrication Engineers

January, 1994 LUBRICATION ENGINEERING

23
TABLE 1

<table>
<thead>
<tr>
<th>No. Chemical Name</th>
<th>CASReg No.</th>
<th>Synonyms</th>
<th>Physical and Chemical Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Chlorotriazine</td>
<td>[4080-31-3]</td>
<td>N/A</td>
<td>60% active</td>
</tr>
<tr>
<td>2. Poly(2,5-furanoxyimino)</td>
<td>[4719-04-4]</td>
<td>1,3,5-triazine-4-carboxaldehyde</td>
<td>10% active</td>
</tr>
<tr>
<td>3. Chloroacetonitrile</td>
<td>[7779-27-3]</td>
<td>-</td>
<td>45% active</td>
</tr>
<tr>
<td>4. Dimethylsulfoxide</td>
<td>[35691-65-7]</td>
<td>-</td>
<td>70% active</td>
</tr>
<tr>
<td>5. N,N-Dimethylformamide</td>
<td>-</td>
<td>-</td>
<td>90% active</td>
</tr>
<tr>
<td>6. Acetone</td>
<td>[600-828-6]</td>
<td>-</td>
<td>90% active</td>
</tr>
<tr>
<td>7. Chloroacetamide</td>
<td>[4113-72-3]</td>
<td>-</td>
<td>90% active</td>
</tr>
<tr>
<td>8. Acetic acid</td>
<td>[628-00-1]</td>
<td>-</td>
<td>90% active</td>
</tr>
</tbody>
</table>

**MIXTURES**

<table>
<thead>
<tr>
<th>Mixture</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hexadecan-1-ol</td>
<td>1,3,5-triazine-4-carboxaldehyde</td>
</tr>
<tr>
<td>2. Methyl alcohol</td>
<td>1,3,5-triazine-4-carboxaldehyde</td>
</tr>
<tr>
<td>3. Isobutanol</td>
<td>1,3,5-triazine-4-carboxaldehyde</td>
</tr>
<tr>
<td>4. 2-Methylbutanol</td>
<td>1,3,5-triazine-4-carboxaldehyde</td>
</tr>
</tbody>
</table>

**TECHNICAL**

Before discussing the specific selection of biocides, the question of what biocides should be used should be considered. In many respects this question is emotional as well as technical. The use of biocides is literally banned in some plants, whether or not they are legally certified and whether or not a demonstrated microbiological need exists. There is no consensus on the level of bacteria or fungi that demand biocide response. There have been numerous recommendations, most of which have been based on potential health effects and not on MWF deterioration that range from 1,000 to 100,000 bacteria per mL. The signal for biocide addition is frequently triggered by physical and chemical signs related to microbial activity (e.g., H₂S and NH₃ odors, slime production, pH drop). Each fluid manufacturer with experience usually can recommend to users the microbial levels requiring biocidal addition. This advice should be combined with the user’s experience to determine the best prophylactic treatment level.

Many are promoted as being "biocidal" or "biostatic," implying either no or limited biological activity in the fluid with no chances in the functional nature of the fluid. Some fluid manufacturers assert that their fluids support the growth of microorganisms but that these are "friendly organisms" that prevent the growth of unfriendly ones. This proposition of some microbes occupying a niche and preventing others from entering is a well accepted premise in microbial ecology. However, nothing but anecdotal proof can be found for this MWF marketing strategy. To the contrary, published work (2) shows that under controlled conditions the same microbes end up in MWFs regardless of whether they are advertised as "friendly."

Biostability as a concept is a biological theory of relativity. There is some objective truth to the assertion that some MWFs are relatively biostable. This fact is conditional, in which biostability is related to both concentration of the fluid and its pH, with high pHs (9.0 and above) favoring biostability (3). Dilution of MWF concentrates beyond a biostability level can ultimately lead to loss of any biostability. However, there is the additional question of specific resistance in which the fluids are resistant to bacteria but not fungi. Use operating situations also contribute to biosusceptibility. Poor plant hygiene adds to the biostability, and long-term retention in the machine sums without replacement also contributes to relative biostability.

In all these cases stated above, uncontrolled microbial growth may lead to premature loss of fluid functional characteristics (e.g., corrosion protection, lubricity). In addition, aesthetically unpleasant results often accompany growth (e.g., malodor, slime).

Earlier it was stated that emotional as well as technical concerns were involved in biocide use. By their function, biocides are defined in the U.S.A. pesticide legislation as economic poisons since they are sold in the marketplace to kill living organisms. Those used in MWFs for control of heterotrophic microorganisms, as stated previously, must satisfy certain legal requirements to earn official...
Biocides are chemical substances used to inhibit, prevent, or destroy microorganisms or other organisms. They are used in a wide range of applications, including in the education of detergents, cleaning products, and water treatment systems. Biocides are typically used to control the growth of microorganisms such as bacteria, fungi, yeasts, and algae. This is important because these microorganisms can cause disease, spoilage, and damage to materials and equipment.

Biocides are used in various industries, including the food, beverage, pharmaceutical, and agriculture sectors. They are also used in domestic applications, such as household cleaning products and personal care items. Biocides are classified into two main categories: broad-spectrum biocides and narrow-spectrum biocides. Broad-spectrum biocides are effective against a wide range of microorganisms, while narrow-spectrum biocides are effective against specific types of microorganisms.

Biocides are also used in the manufacturing of various products, such as paper, textiles, and plastics. They are used to prevent the growth of microorganisms on these products, which can cause spoilage and damage to the products. Biocides are also used in the oil and gas industry to prevent the growth of microorganisms in pipelines and tanks.

Biocides are also used in the agricultural sector to control the growth of microorganisms on crops and in the storage of food products. They are also used in the production of food and beverages to control the growth of microorganisms that can cause spoilage, such as mold and bacteria. Biocides are also used in the pharmaceutical industry to control the growth of microorganisms in the production of drugs.

Biocides are also used in the water treatment industry to control the growth of microorganisms in water systems. They are also used in the pulp and paper industry to control the growth of microorganisms in the production of paper.

Biocides are also used in the chemical industry to control the growth of microorganisms in the production of chemicals. They are also used in the food and beverage industry to control the growth of microorganisms in the production of food and beverages.

Biocides are also used in the automotive industry to control the growth of microorganisms in the production of automotive parts. They are also used in the construction industry to control the growth of microorganisms in the production of construction materials.

Biocides are also used in the agriculture sector to control the growth of microorganisms on crops and in the storage of food products. They are also used in the production of food and beverages to control the growth of microorganisms that can cause spoilage, such as mold and bacteria. Biocides are also used in the pharmaceutical industry to control the growth of microorganisms in the production of drugs.

Biocides are also used in the water treatment industry to control the growth of microorganisms in water systems. They are also used in the pulp and paper industry to control the growth of microorganisms in the production of paper.

Biocides are also used in the chemical industry to control the growth of microorganisms in the production of chemicals. They are also used in the food and beverage industry to control the growth of microorganisms in the production of food and beverages.

Biocides are also used in the automotive industry to control the growth of microorganisms in the production of automotive parts. They are also used in the construction industry to control the growth of microorganisms in the production of construction materials.
The use of pasteurizers has received some support, although this does not necessarily mean it is effective. Physical methods like pasteurization leave no residual protection. This means that even with sterilization, an unlikely event, reinfection of the fluid will not be prevented. In the laboratory, regrowth of survivors in pasteurized MWF reaches and even surpasses original levels in 24 hours. However, if the same heat treatment (60 C) is combined with biocides, there is apparent synergism with much greater effectiveness than with the biocide alone (9).

ECONOMICAL

The cost of MWF biocides per kg. varies as much as tenfold; however, in this case the recommended doses for the two also differ by a factor of 10, making the actual cost per dose about equal. But the actual cost of the treatment should be the least concern. There can be a sequence of events with a drastic domino effect, as follows. Microbiological growth causes fluid failure, fluid must be dumped (fluid cost, disposal cost), system is cleaned (labor cost), system is recharged (labor cost), down-time (inactivity, cost of production loss). Other related possibilities include worker complaints of malodor, illness real or imagined, corrosion of workpieces and tools. This collective list is more than sufficient for paying careful attention to the economic considerations of biocide selection in control of biodeterioration of MWF.

CONCLUSION

The demands on biocide efficacy performance in operating MWF systems are significant. They are expected to have compatibility with all types of fluids, last longer than the make-up rate, and be effective against all types of microbes associated with fluid deterioration. All this in addition to approval by regulatory agencies, as well as workers' committees concerned with health and welfare and only contributing minimally to the cost of the metalworking operation.

REFERENCES


*Note: Recent results from the Triazine Study revealed when only exposure data from the use of neat triazine were considered, no formaldehyde was detected.

DR. HAROLD W. ROSSMOORE (Fellow, STLE) is Emeritus Professor of Biological Sciences and Adjunct Professor of Occupational and Environmental Health Sciences at Wayne State University, Detroit, Michigan. He is also President and Founder of Biosan Laboratories, Inc., Warren, Michigan. He earned a B.S. in Pharmacy, M.S. in Pharmaceutical Chemistry, and a Ph.D. in Microbiology at the University of Michigan.

LEONARD A. ROSSMOORE (Member, STLE) is Vice President and General Manager of Biosan Laboratories, Inc. Biosan is an independent testing laboratory that specializes in solving problems related to microbial contamination in industry. Mr. Rossmoore has been active in this area for more than 15 years, and his personal expertise is in the area of metalworking fluid microbiology. He has authored and presented numerous papers.