Blended Phosphates Effect on Biofilm Development

Written by: William F. Mersch

The use of polyphosphates combined with orthophosphates are typically used in drinking water systems for the control of iron, manganese, hardness salts and of course in the control of corrosion on the system metallurgy. These blended phosphate products also offer a technology where the potential for biofilm development is greatly impeded. The specific choice of polyphosphates used within this product formulation offers a tremendous opportunity for allowing oxidants (i.e.; chlorine, etc.) to penetrate the cell wall of a microorganism.

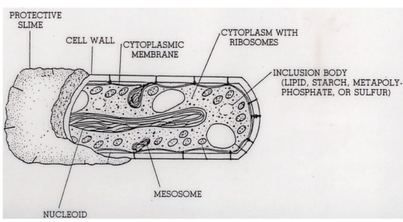

Figure 1 Typical Cell Structure

There are various types of microorganisms that grow within water systems. They fall within two basic categories of either being planktonic (free floating) or sessile (surface-attached). Planktonic microorganisms are present in the bulk water and are typically killed with the chlorine product being fed to the system. The sessile microorganisms are typically found growing actually in or underneath a biofilm. These are much more difficult to control due to the protective film (glycocalyx) of the slimy biofilm. This slimy film may trap other microorganisms and debris acting as a glue and adhering to a surface. These biofilms are the result of secretions from bacterial cells.

Bacterial slime (biofilms) has a negatively charged surface and since chlorine also is negatively charged, it is difficult to penetrate these biofilm masses (i.e. like charges repel). Therefore, a biofilm penetrant is often needed and polyphosphates are able to perform this function. This side benefit of using phosphate chemistry to control biofilm development has allowed drinking water utilities a cost effective means of preventing these biomasses to exist and cause health problems to their customers.

If biofilms are not properly controlled there are health concerns for a municipality to consider as well as the damage to the distribution system piping. This comes in the form of under deposit corrosion. This microbial induced corrosion (MIC) can create a great deal of damage to piping since these anaerobic conditions can cause localized corrosion. This type of pin-hole corrosion is directly related to the extremely low pH conditions that are formed below this biofilm. To change this environment for these anaerobic microorganisms, the bio-penetrant needs to scrub away and disperse this slimy protective coating. Blended phosphate treatment programs accomplish this process very well.

To assure that this biofilm truly is being removed from the distribution system, it is imperative that an accurate measurement be monitored within the bulk water of these distribution systems. That is best realized thru the monitoring of chlorine residuals.

When a biofilm or biomass is present within a bulk water system, it exhibits a demand on the oxidative requirements of the system. When using chlorine based products this increased demand results into an increase in chlorine chemical feed due to an absorption process by the glycocalyx, or protective film of the biofilm. This process eliminates the kill potential of any chlorine absorbed by this film resulting into a waste of chlorine. Most plant operators would certainly feel that by increasing the chlorine feedrate the microbiological growth within the system is obviously being controlled properly, when both the sessile and planktonic populations are most likely growing at an exponential rate.

Impact of Chloramination on Biofilm Development

Chloramination has also presented an interesting twist to the treatment of municipal drinking water supplies. In an effort to reduce trihalomethanes (THM) and haloacetic acids (HAA) there has been an increase in adding ammonia to combine with chlorine thus forming chloramines. There is still THM and HAA formed as well as N-nitrosodimethylamine (NDMA), but in lower levels when compared to straight chlorination treatment.

The biocidal effect of these chloramine compounds is also noteworthy, but caution with chloramination needs to be taken if contact with dialysis equipment is in close proximity. The free chlorine residuals is the critical test however, any free ammonia will contribute to biofilm development, therefore care needs to be taken with regard to chloramination and the ammonia feedrate since it contributes the nitrogen (N) which microbes seek for reproduction. This increase in nutrient availability (N) will result in an increase in biofilm thickness.

In trying to produce chloramines, the reaction is usually driven to completion by slightly over feeding the ammonia side of chemical reaction. Under this treatment approach the excess ammonia (N) provides a nutrient source for microbes to thrive within, producing a very favorable environment that leads to biofilm development. Under these conditions, chloramination has a detrimental effect on the entire system leading to an array of problems that compromises the water quality of the drinking water system.

It is at this point when a total system evaluation is necessary and a proper treatment assessment along with system flow and flushing program must be considered to eliminate the problem.

Benefits of Blended Phosphate Technology on Biofilms

In summary, it is generally accepted that in using a blended phosphate technology, the benefits with regard to microbiological activity within a distribution system are:

1) Elimination of biofilms or the reduction of biofilm development within the system.

2) Reduced corrosion rates of system metallurgy due to the elimination of under-deposit corrosion.

3) Decreased treatment costs especially with regard to chlorination.

4) Safe water for human consumption.

There are certainly additional water quality parameters that are often improved upon as well, such as red water along with improved taste and odor. The sulfur taste and/or smell are often attributed to sulfate reducing bacteria (SRB) which can cause significant damage to the distribution system. Other bacteria's also attribute to the problems within drinking water systems, but SRB growth is typically regarded as the most offensive in terms of taste and odor.

Control of microbiological growth is certainly an essential task of the water plant and we recognize the need for an effective treatment program. Through the use of blended phosphate technology combined with bio-penetrants, the sessile and planktonic growth of a system's bulk water can be easily controlled. All of these chemical approaches will provide for optimization of flushing programs with the end result of fresh and safe drinking water for your customer.

If additional information is needed regarding this Technical Paper, please contact your Viking Chemical representative.