

DROPS OF WATER INFORMATION

Laboratory Notes from Water Systems Engineering

Why Dispersion Chemistry Improves Well Cleaning

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Well cleaning over the past seventy-five years has revolved around the use of acid or chlorine to remove the mineral and biological masses that impact well production. Acids, primarily hydrochloric and sulfamic are used to dissolve the mineral deposits, while chlorine is used to control the biofouling. Chlorine it is thought, and indeed does, kill large numbers of free swimming bacteria; however, it is rather ineffective towards bacteria within biofilm. The oxidative action on the upper layers of the biomass results in a much tougher or denser material.

BIOFILM

Biomass, as a habitat for bacteria is essentially a biofilm formation composed of the bacteria cemented together with the polysaccharide slime that the bacteria produce both as an aid for attachment, as well as a protection against mechanical stress and chemical attack. It is this biofilm that grows, matures, and contains many layers and numerous types of bacteria that ultimately results in production of the so called "clogging" or biofouling of the well environment.

The polysaccharide polymer, which makes up the gelatinous material or slime produced by the bacteria, is not water-soluble although a large amount of water is incorporated in the biofilm structure. Even though it is not solubilized by the chlorine, it is readily attacked by the oxidative action. The oxidization results in a denaturing of the polymer and a collapse to some extent of its water carrying capacity. This collapse and denaturing effect actually produces a much tougher, more insoluble material. The material is biodegradable; however it is less soluble to acid treatments and/or the mechanical agitation of the cleaning process. In this sense, chlorine utilization in cleaning activities often does more harm by

collapsing and tightening the biofilm formation.

DENATURED BIOFILM

Some of the above phenomena are readily discernible in the laboratory with chlorine treatment of laboratory-grown biofilms; however, the effects of chlorine treatment on the biomass have been recorded indirectly in numerous well cleanings throughout the country. Well statistics have shown that there often is a marked slow down following chlorination of biologically contaminated well systems.

This slowdown may appear several days to a month following a cleaning process. It is theorized that this slow down results from the tightening of the biofilm itself and the denatured polymer layers resulting in a less water soluble or penetrable mass. In actuality the slow down may result from a slough off of the denatured layer and movement of the layer toward a more restrictive formation. This movement results in the bridging of pore spaces around the well. The release of this dense top layer is facilitated by the growth of anaerobic organisms positioned deeper in the biofilm and untouched by the chlorine. As these anaerobes grow gas produced as a by-product slowly forces the less permeable layer to release into the flow.

HIGHLY CONCENTRATED WELL CLEANING ENVIRONMENT

In the highly concentrated well cleaning environment (that is as the acid is put in to the well system) mineral deposits are readily dissolved, particularly those of the carbonate compounds which releases the ions of calcium, magnesium, and iron into the solution as well as the carbonate and bicarbonate anionic entities. In addition to these ionic or dissolved forms, partially solubilized crystalline structures of sulfates, oxides, and silicates also impact or crowd the solution. Also present, of course, are the ions of the acid itself.

As the acid attack takes place on the surface of mineral deposits, the products of

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partial dissolution and reformation begin to accumulate on the surface, blocking the acid movement towards the mineral deposit. This is the major reason why agitation is required in order to help remove partially dissolved structures so that the acid can continue to dissolve the more readily soluble mineral compounds. In a typical dissolution process of other types of acid cleaning, agitation or water flow brings more water with less dissolved or suspended solids towards the cleaning reaction. This results in more space for dissolved and partially dissolved products to enter, removing them from the actual site of the reaction. Because the well environment is so highly concentrated and or restrictive, reprecipitating byproducts as well as partially dissolved particles and suspended matter begin to choke the acid cleaning operation. This results in a very inefficient utilization of the acid cleaner.

DISPERSION CHEMISTRY

"Dispersion chemistry is the use of specific polymers to block the attraction of positive and negative forces which account for the formation of salts (compounds), crystals, granules, and colloidal masses."

The use of dispersion chemicals to enhance the cleaning reaction can greatly improve the efficiency of acid treatments. All of the dissolved ions and biomass form and reform during the acid cleaning reaction and choke or slowdown the chemical activity. Let's look at the polymer's effect on each entity and how it frees the reaction to improve acid efficiency.

Salts (Compounds)

The complete dissolving of the crystal deposit releases ions into solution. (One of the simplest acid mineral reactions is that of acid against calcium carbonate which readily dissolves freeing calcium and the carbonate ions into the solution.) The calcium ion is positive while the carbonate ion is negative and as these entities increase in concentration in the dissolution process, the random formation of calcium carbonate is inevitable. With specific anionic (negatively

charged) polymers present, the cationic ion (positive charge) can be neutralized. This removes the cation from the reformation cycle and prevents formation of salts. The negative polymer control of the reformation cycle would apply to most metal salts such as sulfates, oxides and more complex structures which normally makeup deposits in the well environment.

Crystals and Mineral Scale

If calcium carbonate growth continues it becomes a crystal (a granule) large enough to dropout of solution. The crystal is a geometric placement of molecule of the salt in such a way that the formation is repetitive resulting in a latticework or crystal. The highly negative-charged polymer will wrap itself around a positive charged position on a crystal preventing its further growth since the negative side of the salt's molecule must attach itself to the positive position on the crystal for crystal growth to proceed. The repulsive force of this "wrapping" is the *dispersion effect*, capable of removing the crystal from the field of reaction. This reduction in the concentration of insoluble-solids greatly increases the ability of the acid to solubilize the lesser-soluble mineral compounds (i.e., sulfates, oxides, and phosphates).

Colloidal Masses

If chlorine or other strong oxidizing agents are not incorporated in the cleaning activity, the mechanical agitation of an acid solution alone will begin to partially break apart the biomass. Since 75 to 80% of the biomass is an insoluble polysaccharide polymer, this break up results in movement of fragments of the polysaccharide material into the free flowing water. Without dispersion-chemistry this polymer material merely reattaches, reforming the saccharide polymer again on other surfaces or mending its own biofilm formation. The uniqueness of dispersion-chemistry is such that the exposed areas of the fragmented polysaccharide polymer offer excellent attachment (positive sites) for the negative-charged dispersion polymers.

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This attachment results in dispersion of the polysaccharide material by producing a molecule with a soluble side (anionic polymer) and insoluble polysaccharide portion. This dispersion assures it of being maintained in solution or suspension.

In addition the presence of the negative charge dispersion polymer prevents the repolymerization of the saccharide monomer so that now the polymer is much shorter and less adhesive or attachable to the remaining polysaccharide film. In essence, we have solubilized a portion of that film and taken it into the water phase. This allows us to systematically remove the biofilm and at the same time be able to transport it from the system during flush out.

SUMMARY

Solubility of both minerals and organics is substantially increased through the use of dispersion chemistry primarily do to its blocking effect on the force of attraction. As the surfaces of chemical entities (ions, molecules, crystals, polymers, or aggregates) become coated with a negative charge, the repulsion of similar charges results in maintaining these products in solution or suspending them in the cleaning liquid. The reaction prevents reprecipitation and agglomeration of particles toward larger sizes, which other wise would block the solubilization reaction of the cleaning solution or eventually settle, and be difficult to remove from the well system.

Dispersion chemistry has been used in industrial applications for many years as polyelectrolyte control polymers in boilers and cooling systems for scale or deposit control. The use of polymers in severe acid conditions however does require special configurations so that they are active at the low pH levels necessary for well cleaning.

Dispersants available on the market that are NSF Certified for potable well use include Johnson Screen's NW-310, Johnson Screen's Well Cleaner, Layne Christensen's QC-21, and Design Water Technologie's Unicid Catalyst.

For additional information or assistance in identifying your well's problem, please contact our office.

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