by Pat McCool, KRWA Consultant

Coagulants 101: The use of coagulants in clarification plants in Kansas

Surface water treatment plants in Kansas can be put into the two categories: clarification plants and softening plants. Softening plants add high dosages of lime and carbon dioxide to significantly reduce the hardness of the water. Most small water treatment plants in Kansas are clarification plants. In clarification plants softening is not an objective; the removal of turbidity and total organic carbon (TOC) with the use of coagulants are a primary objective.

An operator's and others' understanding of the coagulants and the best selection/use of coagulants is very important for three reasons. First, the use of coagulants is needed to produce drinking water that is safe for human consumption. Second, the coagulants are needed to meet the regulatory requirements for turbidity and for TOC removal. Third, the use of coagulants may represent 60% to 75% of the total chemical costs of treating the water; this is where significant cost savings are possible.

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Coagulants are chemicals added to the water to destabilize particulate suspensions (e.g., turbidity) and to produce flocculent particles that will settle out and/or will be filtered out of the water. Coagulants are also used to form precipitates that will adsorb organic matter (e.g., TOC) and that will be removed also by settling and/or filtration.

The different types of coagulants used can be put into any one of four groups. In many cases, two or three types may be used at the same time in a plant. Each type has advantages and disadvantages; the operator's determination of which type(s) to use and at what treatment process location(s) is very important in meeting regulatory requirements, keeping costs low, and ensuring "smooth" operations.

Prehydrolyzed metal salt solutions are sold in containers called "totes," holding approximately 250 gallons.

Simple metal salts

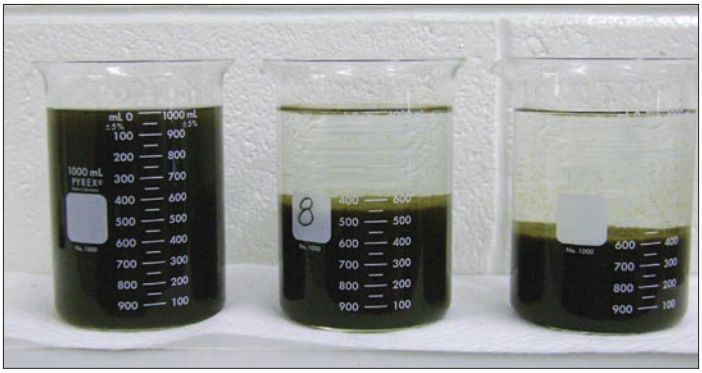
The first group and most widely used coagulants are simple metal salts. Aluminum sulfate, ferric sulfate and ferric chloride are the three main coagulants in this group. These chemicals can be purchased in bulk for larger plants or in bagged or solution form for smaller systems. This group has the advantage of usually being the lowest cost for treatment. That is why the larger plants use this group extensively. The disadvantages of this group include the need for more additional chemicals (usually lime, sodium hydroxide and/or soda ash) for pH adjustment and the need for more operator control/attention/time to adjust feed rates due to changing raw water quality turbidity.

Prehydrolyzed metal salts

The second group is the prehydrolyzed metal salts. This group has gained popularity and use in smaller water treatment plants. These chemicals are similar to metal salts but their chemical structures have been changed so that these chemicals react differently in the water being treated. The prehydrolyzed metal salts are sold in a liquid solution form. Examples of prehydrolyzed metal salts are polyaluminum chloride and aluminum chlorhydrate.

One advantage of prehydrolyzed metal salts is that these chemicals work better than the simple metal salts over a range of changing raw water quality conditions. Thus, adjustments of feed rates are not needed as often. Another advantage is that these chemicals work better in cold, clear raw water than the simple metal salts.

The use of prehydrolyzed metal salts does not lower the pH of the water as much as simple metal salts. Consequently, the use of pH adjustment chemicals is not as great, resulting in some cost saving for the pH adjustment



From L. to R.: Settling test results at 0 minutes, 15 minutes, and 30 minutes.

chemicals. Another advantage is that the companies selling prehydrolized salts usually give good technical assistance and on-site testing to determine which chemical to use and at what dosage.

There are three possible disadvantages of using prehydrolyzed metal salts. The first is that the buyer does not know the particular type of chemical and the chemical's concentration in the purchased solution. For instance, the chemical solution may have a name something like "BestCoag 1492" but the particular coagulant chemical and its concentration is probably not listed on the container or the safety data sheet, and may not be provided by the seller.

Another advantage is that the companies selling prehydrolized salts usually give good technical assistance and on-site testing to determine which chemical to use and at what feed rate.

Another possible disadvantage is that the buyer may know that the chemical is polyaluminum chloride but does not know the particular chemical structure, its basicity or its concentration in solution. Not knowing this information makes it difficult for an operator to compare one chemical to the many others based on chemistry. Thus, the operator has to rely on performance and treatment cost. That is a good way to compare coagulants.

The second disadvantage of prehydrolyzed metal salts is that they do not remove TOC as well as simple metal salts at the same dosage. Prehydrolyzed metal salts may remove as much TOC, but most likely at a higher dosage and a higher treatment cost.

The third disadvantage is that the treatment cost for using prehydrolyzed metal salts is high and may be 60% to 75% of the total chemical treatment costs. This disadvantage must be addressed against the advantages.

The use of prehydrolyzed metal salts has definite advantages for the small clarification plant but it comes with a substantial cost. It may be such that using a different prehydrolyzed metal salt, or reducing the dosage, or adding a coagulant aid could lower the costs without sacrificing performance. Each plant must be evaluated to determine which chemical(s) should be used and the application point(s) to save on coagulant costs.

A solids contact basin similar to those used in small, surface water treatment plants.

Polyelectrolytes

The third group is high molecular weight, synthetic organic compounds called polyelectrolytes. Polyelectrolyes adsorb onto most particles in water and aid in floc formation, settling, and filtration removal of the particles. Polyelectolytes are usually added in combination with the use of simple metal salts or prehydrolyzed metal salts. Polyectrolytes can be added directly to the water being treated. Sometimes they are already blended in solution with prehyrolyzed metal salts.

Polyelectrolytes can come in three forms: cationic (positively charged), anionic (negatively charged), or nonionic (no charge). Polydiallyldimethyl ammonium chloride (known as polyDADMAC), epichlorohydrin dimethylamine (known as epiDMA), and polyacrylamide are three main polyelectrolytes. Polyelectrolytes are added at very low dosages of 1.0 ppm and much less.

Polyelectrolytes may be used in conjunction with other coagulants as a primary coagulant, or as a "filter aid" to aggregate and strengthen the floc. The proper use of polyelectrolytes sometimes gives great results for very little treatment cost.

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Coagulant aids

The fourth group is coagulant aids. These are compounds that aid other chemicals added in the coagulation and/or flocculation process. Polyelctrolytes and bentonite clay are used as coagulant aids. Both these compounds are added with other coagulants to hopefully give better coagulation/flocculation/settling.

Bentonite clay is being added at one water plant to reduce treatment costs associated with prehydrolyzed metal salts. At another plant, bentonite clay is being added with ferric sulfate to enhance turbidity removal and to increase TOC removal. A third plant has recently begun adding ferric chloride to aid the present prehydrolized metal salt / polyelectrolyte addition in turbidity and TOC removal.

Jar testing and solids contact basins

The operation of all clarification plants is in many ways similar – and yet in many ways, the operation from one plant to the next is quite different. Thus, what works at one plant may not work well at another. But in most cases, there may be several coagulant(s) or combinations that may work in a particular plant. Each plant should be evaluated to determine if there is a better selection, application point(s) and dosage of coagulants.

The goals are: 1) meeting turbidity standards and TOC removal percentages; and, 2) ease and reliability of the operation given the amount of operator attention and time spent at the plant. If the goals are met, then the best of several selections and dosages is the one that reduces treatment costs (e.g., measured as $ per 1,000 gallons treated) to a minimum.

Jar testing is used at some plants to help determine coagulant dosages. Jar testing is a tool to help determine but jar testing does not necessarily give good information. Jar testing was developed many decades ago when the coagulation, flocculation, and sedimentation processes were in separate basins. The jar testing was set up to reflect processes in these basins.

Today, most small clarification plants have a solids contact basin that has a solids reaction zone that is constructed with a settling zone in the same basin. The reaction zone has increased concentration of solids recycled from the settling zone. Thus, the dosages of chemicals in the typical jar testing do not simulate the much higher concentrations of the same chemicals in the solids reaction zone of solids contact basins.

The monitoring and evaluation of the solids levels in the solids reaction zone and height of the sludge blanket in the settling zone are much more valuable to an operator than jar testing. For example, a 10-minute or 30-minute settling test of the solids in the reaction zone will give the operator good information on how the plant is operating and if changes are needed in increasing or decreasing the level. Changing a chemical dosage alone will not necessarily increase the reaction zone solids level that is also affect by the settled sludge blowdown amounts and the on/off operation of the plant.

In a solids contact basin, the reaction zone solids level is just as important as chemical dosage. This is because in the reaction zone there are many reactions and processes being carried out. The good design and operation of a solids contact basin has resulted in many such plants performing jar tests on a very limited basis.

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I would like to remind readers of sessions that the upcoming KRWA Annual Conference that address water treatment. These include a preconference session on Tuesday, March 24 entitled “Water Treatment Processes”. That session will discuss coagulation, flocculation, sedimentation and filtration. Disinfection and meeting disinfection byproducts requirements will also be covered. Check the program that was mailed to you in early January and also, refer to the reprint of the program in this issue of *The Kansas Lifeline*.

Also, if you would like assistance in evaluating your plant’s coagulant addition and in discussing possible changes, I encourage you to contact KRWA.

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