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## Technical Bulletin

## ENHANCED COAGULATION

### Introduction

On July 29, 1994, the US EPA proposed the Disinfectants/ Disinfection Byproducts Rule (D/DBPR) (59FR 38668). The D/DBPR was developed as a negotiated rule through the efforts and participation of state and local agencies, elected officials, consumer groups, environmental groups, and the drinking water industry. These negotiations brought about the following requirements that were implemented in November 1998.

### D/DBPR Stage 1 Requirements

Compound	MCL/MRDL
TTHM	0.080 mg/l
Haloacetic Acids (HAA5)	0.060 mg/l
Bromate	0.010 mg/l
Chlorite	1.0 mg/l
Chlorine	4.0 mg/l
Chloramine	4.0 mg/l
Chlorine Dioxide	0.8 mg/l

More specifically, this chart shows how Enhanced Coagulation and various source water conditions interrelate in terms of the **required removal rates** of TOC in systems using conventional treatment.

Source Water	Alkalinity		
	0 to <60	60 to <120	>=120
<b>TOC</b>			
0 to < 2.0	N/A	N/A	N/A
>= 2 to < 4	35%	25%	15%
>= 4 to < 8	45%	35%	25%
>= 8	50%	40%	30%

### Ferric Chloride for Enhanced Coagulation

Since the process of enhanced coagulation was introduced, Ferric chloride has repeatedly been shown to have a dramatic capacity to remove the soluble and semi-soluble organic materials that make up TOC. Many papers have reported that Ferric Chloride is the most viable approach for removing DBP precursors from raw water.

The process of enhanced coagulation focuses on the removal of naturally occurring organic materials from potable water supplies. These materials if chlorinated have the potential to form disinfection by-products (DBP's). The basic premise behind enhanced coagulation lies in the ability of Ferric Chloride to remove TOC, THM precursors, and color producing organic materials. Much is left to be learned regarding the mechanisms by which Ferric Chloride accomplishes enhanced coagulation, however, by closely examining current methods we can deduce to some extent what mechanisms are taking place.

Enhanced Coagulation is accomplished in three distinct treatment phases. First, Many TOC compounds exist in water sources as semi-soluble or even soluble compounds. Many of these TOC compounds must be protonated to be de-solubilized and separated from solution. The common approach to this process is to reduce the pH of the water. This can be accomplished through the addition of mineral acids such as hydrochloric or sulfuric acid or through the addition of a Lewis acid such as Ferric Chloride. This process separates the organic molecule from the water and creates a micro-particle or micro-droplet. Although separated from solution, due to its small size, it is not yet in a condition to be physically removed.

The next step occurs as the micro-droplets of the organic materials are adsorbed on the hydrated ferric chloride (Ferric Ox hydroxide) floc. The rate and efficiency at which this adsorption takes place is related to the size and number of hydrated floc particles. When the floc particles are small and numerous they will have a greater charge to surface area ratio; and the level of organic material adsorption will be high. When the floc particles have grown in size, the total collective surface area will be less and the number of particles will be fewer. The charge to surface area ratio will, therefore, be lower and lead to a corresponding loss in adsorption efficiency. The point being that the process is more efficient early on when the floc particles are just forming. This leads us to recognize the need for high energy rapid mixing for coagulant dispersal.

Finally, given favorable mixing conditions, the small floc particles, in colliding with one another will form large aggregates that can be removed through gravity settling. If necessary, the settling rates of these aggregates can be improved through the use of polyelectrolyte polymers. The sludge from this process is accumulated and processed for residual removal.

### **Other issues**

Alkali usage – because enhanced coagulation requires low pH conditions the addition of make-up alkalinity is unavoidable. For hard waters, softening processes are often initiated after enhanced coagulation. However, it is important to recognize the potential for resolubilization of some TOC materials with high pH. Therefore, it is sometimes critical to provide solids removal for enhanced coagulation products before starting the softening process. Accomplishing enhanced coagulation in plants with limited physical resources can present some problems. Higher sludge volumes will be experienced due to higher coagulant dosages.

### **Benefits of Enhanced Coagulation with Ferric Chloride**

- Very often the only economically viable solution
- Orders of magnitude better results than most other processes or coagulants
- Highly flexible treatment parameters
- Relatively easy to implement
- Capital investment low
- Numerous options for low cost disposal of residuals

### **How California Water Technologies can help**

California Water Technologies' is committed to the municipal water industry. We are a producer of high quality Ferric Chloride. Our technical staff can help you analyze your treatment needs and develop a strategy to meet the D/DBPR requirements. To get a step up on meeting the regulations please call **(866) 337-7427** to talk with one of our technical representatives.