

## HRC TECHNICAL BULLETIN # 4.1.4

Hydrogen Release Compound **HRC™****HRC Application and Chemical Oxidants**

The use of chemical oxidation in groundwater remediation is characterized by the use of two main strategies. The first is the use of Fenton's Reagent that involves that catalysis of hydrogen peroxide by an iron salt – typically iron sulfate. This generates highly reactive free radicals that chemically oxidize contaminants. The second approach involves the use of permanganate – typically potassium permanganate that also oxidizes the contaminants.

Chemical oxidation is an active process that requires the handling of hazardous chemicals on-site. The following points describe other basic differences between active chemical oxidation and the gentler HRC stimulated biological reductive dechlorination.

1) *HRC is More Cost Effective in Treating Dissolved Plumes.* Chemical oxidation requires contact between the short-lived free radical generated and the target compound. This requires that the chemical oxidant be injected into many points at very close spacing. It also requires very large quantities of chemical reagents. These characteristics make chemical oxidation approaches much more costly than a simple installation of passive releasing HRC. In comparison to HRC, chemical oxidation of a dissolved phase plume may cost three to four times that of a similar HRC plume treatment.

2) *HRC is Safe.* Both the permanganate and Fenton's Reagent technologies are dangerous to handle (both the reagents and the reactions are dangerous). Patents which have strong safety considerations are held by many of the companies offering these services which focus on methods of application that revolve around these safety and efficacy issues. HRC, on the other hand, is safe to handle when following the instructions and does not produce excessive heat or explosive conditions.

3) *Chemical Oxidation Prohibits Natural Attenuation.* Chemical oxidation disrupts the anaerobic condition of the aquifer. As a result, once chemical oxidation is applied in an area, natural dechlorination activity is inhibited. Thus, one cannot make the argument that chemical oxidation will treat the majority of the contamination, leaving the remaining contamination to natural attenuation. Due to the resulting oxidized environment, natural attenuation of the chlorinated solvent contaminant simply will not occur. At several sites where chemical oxidation has been applied, HRC has been proposed as a follow-on process to restore the natural attenuation processes to ensure continued contaminant degradation.

4) *Chemical Oxidation may Produce Undesirable By-Products.* In the chemical oxidation of chlorinated hydrocarbons it is not completely clear what by-products are generated. The exposure of contaminants and even background organic matter to high-energy free radicals is not a straightforward proposition. Some reports on the formation of chlorinated derivatives of a questionable nature such as chloramines have appeared in relation to Fenton's Reagent, and the

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use of potassium permanganate has been shown to produce hexavalent chrome contamination plumes from naturally occurring chrome deposits. HRC produces none of these negative effects.

The Advantages of Using Slow-Release Compounds

Given that bioremediation is a viable option for the accelerated natural attenuation of contaminated sites, the following are some advantages of using slow-release compounds over active chemical oxidation systems.

#### 1. Low Capital, Design, and O&M Costs:

Since the slow-release compounds are part of a passive, *in situ* approach, substantial design, capital, and operations/maintenance (O&M) costs are avoided. Actively engineered systems such as a chemical injection well arrays are expensive, time-consuming, and often burdened with costly and extensive design considerations.

#### 2. Environmental Safety:

With respect to HRC, the ester simply degrades into two naturally occurring, safe compounds—glycerol and lactic acid, from which very low concentrations of dissolved hydrogen is derived biologically. Chemical oxidation on the other hand has been shown to cause secondary groundwater pollution in the form of hexavalent chrome contamination.

#### 4. Safe Application and Treatment:

The use of HRC avoids the stated hazards of using permanganate or Fenton's Reagent. Chemical oxidation systems on the other hand have been shown to be very dangerous to apply, and require highly skilled delivery personnel with emergency/ health and safety personnel on standby.

#### 5. Applicability at Difficult to Manage Sites

Slow-release compounds are ideal for sites where geological or physical conditions make active systems inappropriate. Particularly in clay soils, where transport of the transient hydroxyl radical generated in chemical oxidation is difficult, the slow release of diffusible lactate and hydrogen from HRC has advantages.