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Is There a Difference Between "Catalyzed Hydrogen Peroxide" and "Stabilized Hydrogen Peroxide"?

Several clients have contacted us recently regarding in-situ chemical oxidation treatment programs utilizing "stabilized hydrogen peroxide" (SHP), as opposed to "catalyzed hydrogen peroxide" (CHP). Based upon the nature of those discussions, there appears to be a perception that a significant distinction exists between SHP and CHP. However, the difference is semantic. Experienced practitioners have used peroxide stabilizers as an essential part of peroxide in-situ chemical oxidation (ISCO) applications since the earliest development of our industry. In an appropriate and well-designed field application, the use of catalysts and stabilizers can be adjusted to fit site-specific conditions and the evolving nature of an injection to order to achieve treatment objectives.

The reaction of transition metals such as iron with hydrogen peroxide is widely known as a vigorous and exothermic reaction. The need for stabilizers to control hydrogen peroxide degradation for ISCO was recognized as early as the mid 1980's (e.g., Brown and Norris, 1986). Beginning in the early 1990's, research by Rick Watts and coworkers (Tyre et al., 1991; Watts et al., 1992; Watts et al., 1994) demonstrated that naturally occurring iron and other transition metals in soil were capable of catalyzing hydrogen peroxide, and in many cases further addition of iron (such as ferrous sulfate) was unnecessary. However, catalysis of the peroxide to generate radicals is necessary in order to destroy organic contaminants. The key is to control the rate at which that catalysis occurs.



During our development of the Geo-Cleanse[®] Process in the early to mid 1990's, we also recognized the need for stabilizers to control the reaction and to achieve effective subsurface distribution of hydrogen peroxide (Wilson, 1996). We learned that with careful consideration of the site conditions, treatment objectives, and a detailed process monitoring program during the field application, CHP offered an extremely flexible technology that could be adapted to remediate sites under a wide range of application conditions. Hydrogen peroxide concentration, rate of injection, the use and concentration of stabilizer, and the use and concentration of catalyst, could all be adaptively modified over the course of an injection program to respond to evolving site conditions. In sensitive situations in which slow reaction rates are desired, the injection can be conducted with relatively high concentration of stabilizer, no additional catalyst, dilute peroxide concentration, and a slow injection rate. Under these conditions, little or no increase in groundwater temperature (reflecting the reaction rate of the peroxide) can be observed, and peroxide lifetime in the subsurface is long (months in some cases). In other situations a more aggressive treatment program may be desired. For example, Geo-Cleanse has been very successful coupling ISCO with enhanced product recovery of coal tar at manufactured gas plant sites. We utilize the combination of surfactant-like properties of peroxide and peroxide oxidation products, coupled with the enhanced circulation and heat production that can be generated from reaction of hydrogen peroxide with added or naturally-occurring iron, to improve mobilization and recovery of coal tar in addition to oxidation of immobile residuals. This achieves more complete remediation of coal tar-impacted sites at a lower cost and in a shorter period of time.

There is little doubt that, in the absence of stabilizers, hydrogen peroxide may degrade rapidly and, as a result, yield little effective treatment. For example, in a series of column tests Chen et al. (2001) found high degradation rates and no significant transport of peroxide when hydrogen peroxide at up to 1% concentration was introduced to a column



containing soil with high iron concentration (12,950 mg/kg) and a stabilizer was not used; these authors concluded that stripping of trichloroethylene (TCE) due to oxygen gas formation in the column was the primary mechanism of TCE loss from the column. In contrast, Baciocchi et al. (2004) found that when a phosphate stabilizer was added, the degradation of a 2% hydrogen peroxide solution during transport in column tests was negligible and that TCE treatment was much more effective than in identical soil column tests performed without the phosphate stabilizer. The same contrast is evident in field applications. Cronk et al. (2012) reported that injecting hydrogen peroxide with a ferrous iron catalyst resulted in significant heat production, rapid peroxide degradation, and buildup of subsurface pressure from oxygen gas production, which in turn resulted in "daylighting" of peroxide solutions to the surface and associated safety concerns; in contrast, injection of hydrogen peroxide with phytate (a

phosphate compound that stabilizes hydrogen peroxide) resulted in much slower degradation of the peroxide and relatively little pressure increase or offgas production, and as a result achieved better peroxide distribution in the subsurface.

These studies draw the same general conclusions that others first recognized more than 25 years ago: hydrogen peroxide ISCO requires proper stabilization for effective treatment. Thus stabilization and the use of "SHP" has been standard practice by experienced ISCO practitioners since the early stages of our industry; there really is no significant difference between SHP and CHP as practiced by an experienced vendor. Geo-Cleanse utilizes stabilizers and other amendments in association with a detailed process monitoring program in order to deliver effective peroxide ISCO treatment programs.

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