

Accelerated Reductive Catalysis™: A New Process for Treatment of Emerging and Conventional Contaminants

Jeffrey L. Pintenich (jpintenich@brwncald.com)
(Brown and Caldwell, Nashville, TN, USA)

William A. Farone (Applied Power Concepts, Inc., Anaheim, CA, USA)

James M. Claffey (Brown and Caldwell, Upper Saddle River, NJ, USA)

Background/Objectives. Accelerated Reductive Catalysis™ or ARC™ is an effective water and wastewater chemical reduction process invented by Dr. William A. Farone, founder of Applied Power Concepts, Inc. This new technology is capable of reducing a wide variety of compounds and elements in an accelerated time period through the specialized application of proprietary catalyst formulations. Recent process tests have shown successful treatment of 1,4-dioxane, chlorinated hydrocarbons, chromium, selenium, and nitrate. In this process, reduction of contaminants is accomplished ex situ by reaction of a hydrogen source with a constituent to produce an environmentally acceptable end product. The reduction is catalyzed using relatively inexpensive proprietary catalysts that are recovered and reused continuously, and further accelerated through the use of high shear mixing. The process has been demonstrated in the laboratory on a bench- and pilot-scale for several chemicals of importance. Reduction of contaminants is indicated in many cases where oxidation is incomplete, more expensive, or produces toxic intermediates. APC has studied reduction of most environmental contaminants over the last 30 years to determine ways to improve the kinetics and the mechanisms of the reactions.

Approach/Activities. The usual concept employed in the APC laboratory is to first perform a thermodynamic analysis of potential reduction reactions to obtain the preferred pathways and then to follow up with bench-scale experiments for a rough idea of the kinetics. Small pilot studies can then be performed in equipment that mimics a scaled-up system to develop parameters for field demonstration. The experiments are performed with excess hydrogen from either the gas or other hydrogen sources. For environmental remediation reactions the concentrations of the contaminant are often relatively low. To enhance ex situ reaction kinetics one uses a large excess concentration of reducing reactant, a catalyst when possible, and agitates the mixture as much as possible.

Results/Lessons Learned. In the studies reported below the measurement were made by standard techniques, usually GC/MS or LC/MS techniques for the lowest levels and GC or LC for the higher levels. The following systems have been studied in some detail.

- 1,4-Dioxane is easily reduced to ethanol using hydrogen or NaBH₄. For example, water with 100 µg/L of dioxane was reduced to less than 1 µg/L.
- Chlorinated ethenes are easily reduced to ethene and ethane using hydrogen, NaBH₄, or other reducing agents. A wide variety of initial concentrations have been tested and MCLs achieved.
- THMs have been reduced from the 80 µg/L level typical of many treated (chlorinated) waters down to less than 10 µg/L using hydrogen or NaBH₄ in 10 to 15 minutes.
- Perchlorate is reduced to chloride (non-detect in perchlorate and chlorate) using hydrogen or NaBH₄.
- Nitrate is reduced to nitrogen gas using Na₂S₂O₅ or NaBH₄. Levels of several hundred mg/l have been studied. Reductions to MCL are achieved.

- Selenium in the form of selenate can be reduced to selenite and removed through a combination of reduction and adsorption. Selenate was reduced from 100 mg/L concentration of sodium selenate (55 mg/L as Se) to less than 1 mg/L in one test (using LC analysis) and from 100 µg/L selenate (55 µg/L as Se) to below 1 µg/L of selenate (using LC/MS/MS analysis).

Hexavalent chromium has been reduced to trivalent chromium at the MCL.