PCBs and Persulfate

Polychlorinated biphenyls (PCBs) are persistent environmental contaminants that were used in a variety of industrial applications, including coolants and lubricators for transformers and other electrical equipment. They have been identified as potential cancer-causing agents and, as a result, their production and use were halted in the late 1970’s. However, due to their low reactive properties which were of value in their industrial use, they can persist in the environment for long periods of time, and continue to represent an on-going concern as a health risk. An estimated 30% of the hazardous waste sites on the National Priority List contain PCBs.1 Figure 1 shows a generalized structure for the family of PCBs, which include 209 different structural species (congeners), depending upon the number and location of chlorine atoms present. Closely related to PCBs are the structurally similar dioxins, shown in Figure 2, which also have associated health risks due to their presence in the environment.

Due to their low reactivity, there are not many remediation approaches available to clean-up an impacted site. If the contamination is at or near the ground surface, excavation is often the remedial choice. At this point, the contaminated soil can be disposed of at a licensed landfill or incinerated. Both of the options may be expensive, and there is some indication that incineration may generate dioxins.

Recently, the use of activated persulfate for the in situ or ex situ treatment of soils contaminated with PCBs has been explored as an option to the standard dig-and-haul approach. While PCBs are somewhat resistant to oxidation within the environment, Klozur® activated persulfate generates strong radical oxidizing species, sulfate and hydroxyl radicals, which are capable of destroying very recalcitrant compounds. Several laboratory studies have demonstrated the efficacy of activated persulfate on PCBs. Killian et al1 and Hoag et al2 show that heat activation of persulfate can readily destroy PCBs in an aqueous system. In addition, several studies2,3,6,7 show that blending contaminated soils with lime and persulfate can significantly reduce the soil and groundwater PCB concentrations, and that destruction of PCBs is not congener specific2, or in other words, equally effective across the broad range of chlorine ranges. Cassidy7 showed that the destruction of PCBs (and PAHs) in sediments with lime activated persulfate was not due to simple lime entrapment of the PCBs, but due to actual persulfate-induced oxidation. Cassidy’s study6 showed a direct correlation between persulfate concentration and PCB destruction, reaching levels as high as 90% reduction in heavily contaminated sediments, which also contained significant amounts of other polychlorinated aromatic hydrocarbons (PAHs). Similarly, Yukselen-Aksoy et al4 demonstrate that heat or high pH activated persulfate is effective in destroying 60 – 90% of the PCBs spiked into either kaolin or glacial till type soils after just seven days.

It must be pointed out that there has not been a systematic exploration of potential daughter product formation from the persulfate oxidation of PCBs that has been published. Killian et al3 utilized a gas chromatograph for their analysis of PCB concentrations (primarily Aroclor 1242). Their published chromatographs demonstrate a reduction for all peak intensities after exposure to heat-activated persulfate. This would indicate that there is not a significant increase in intermediate concentrations, specifically dioxin formation, which would have resulted in the growth of new peaks in the scans. However, the other published studies did not specifically look for intermediates such as dioxin formation.
While it has been shown in the laboratory that activated persulfate can readily oxidize and destroy PCBs, application in the field can be problematic. PCBs have a very low water solubility and a high absorbance to soils. As a result, most of the PCBs found in the environment will be bound to the soil in the saturated zone or within the soil in the vadose zone. Conversely, activated persulfate oxidation chemistry preferentially takes place in the aqueous phase. Thus, successful application of Klozur activated persulfate for the treatment of PCB contaminated soils requires either sufficient blending of the soils with the persulfate, as an example through rigourous in situ soil blending or ex situ blending through a mill, or through the aid of surfactants and or solvents to enhance the desorption rate of the PCBs off the soil. Figure 3 shows the effects in a laboratory treatability study of surfactant addition to a lime- activated Klozur persulfate treatment of PCBs in a tight clay formation after twenty one days. In addition to surfactant or solvent addition, application of heat or alkalinity can positively impact the desorption of the PCBs from the soil surfaces.

As a result, with proper application to the soil and subsurface, Klozur activated persulfate may be a viable option for the treatment of PCBs as compared to land-filling or incineration. Application of activated persulfate may be a stand alone remediation technology. However, it could be considered as part of an overall treatment train approach coupled with a dig-and-haul. The addition of the activated persulfate would reduce the PCB contaminant levels to a point where non-hazardous land-fill may be an option, thus resulting in an overall reduction of site clean-up costs.

References


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