

Technology review and evaluation of different chemical oxidation conditions on treatability of PFAS

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Abstract

Per- and polyfluoroalkyl substances (PFAS) are a class of stable compounds widely used in diverse applications. These emerging contaminants have unique properties due to carbon–fluorine (C–F) bonds, which are some of the strongest bonds in chemistry. High energy is required to break C–F bonds, which results in this class of compounds being recalcitrant to many degradation processes. Many technologies studied that have shown treatment effectiveness for PFAS cannot be implemented *in situ*. Chemical oxidation is a demonstrated remediation technology for *in situ* treatment of a wide range of organic environmental contaminants. An overview of relevant literature is presented, summarizing the use of single or combined reagent chemical oxidation processes that offer insight into oxidation–reduction chemistries potentially capable of PFAS degradation. Based on the observations and results of these studies, bench-scale treatability tests were designed and performed to establish optimal conditions for the formation of specific free radical species, including superoxide and sulfate radicals, via various combinations of oxidants, catalysts, pH buffers, and heat to assess PFAS treatment by chemical oxidants. The study also suggests the possible abiotic transformations of some PFAS when chemical oxidation is or was used for treatment of primary organic contaminants (e.g., petroleum or chlorinated organic compounds) at a site. The bench-scale tests utilized field-collected samples from a firefighter training area. Much of the available data related to chemical oxidation of PFAS has only been reported for one or both of the two more commonly discussed PFAS (perfluorooctane sulfonic acid and/or perfluorooctanoic acid). In contrast, this treatability study evaluates oxidation of a diverse list of PFAS analytes. The results of this study and published literature conclude that heat-activated persulfate is the oxidation method with the best degradation of PFAS. Limited reduction of reported PFAS concentrations in this study was observed in many oxidation reactors; however, unknown mass of PFAS (such as precursors of perfluoroalkyl acids) that cannot be identified in a field collected sample complicated quantification of how much oxidative destruction of PFAS actually occurred.

1 | INTRODUCTION

Per- and polyfluoroalkyl substances (PFAS) are a class of stable compounds widely used in engineering, electrical, chemical, plastics, and medical industries for diverse industrial, commercial, and consumer applications, notably in fire retardants, aqueous film forming foams (AFFF), surfactants, oil and water repellent coatings, and in mist suppressants used in chromium plating. PFAS are composed of a wide range of substances with very different physical and chemical properties from each other. The PFAS families can be divided into two pri-

marily categories, such as polymer and non-polymer (Buck et al., 2011). The current article will be referring to non-polymer compounds, both perfluorinated and polyfluorinated compounds, when the PFAS will be used to describe multiple families. These compounds have unique properties due to carbon–fluorine (C–F) bonds, which are some of the strongest bonds in chemistry, providing these chemicals with high surface activity, simultaneous hydro- and lipophobic properties; stability in the presence of heat, acids, and bases; and recalcitrant to many forms of physical, chemical, and biological degradation. Increasingly, public health, environmental attention, and regulatory concern