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Assessment of thermal, ultraviolet, ultrasonic, and alkaline methods for producing sulfate radicals in the advanced oxidation processes

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***Abstract*---Sulfate free radicals with high oxidation potential have focused on developing advanced oxidation processes based on sulfate radicals in recent years. These radicals can be created by proxy monosulfate (PMS), and persulfate (PS), these sulfate radicals can be produced through different activation methods. The purpose of this article is to evaluate thermal, ultraviolet, ultrasonic and alkaline methods for producing sulfate radicals. Although its most widespread application is the removal of micro pollutants, its use for wastewater disinfection is increasing. In the last part, the current problems and future prospects of SR-AOPs for applying the above methods are concluded.**

Introduction

Water is at the core of sustainable development. The world's population growth, industrialization, and climate change have led to an alarming decrease in freshwater resources and their availability, thus posing a significant challenge worldwide. By 2030, the world will face a 20% water deficit. [1] Reclamation and reusing wastewater can be a necessary alternative to reduce water stress in some areas. The main danger in the reuse of treated wastewater comes from the presence of pathogenic microorganisms. These pathogens are currently responsible for waterborne diseases that kill thousands of people worldwide each year. For this purpose, disinfection is a vital process to remove pathogenic or non-pathogenic microorganisms, and so far, chlorination is the most common disinfection process. Although chlorination is considered to be an ideal disinfection process, as it complies with almost all the conditions to be considered, it has some important disadvantages, such as the formation of potentially dangerous disinfection by-products(DBPs) such as trihalomethanes(THMs) and haloacetic acids(HAAs) [2] [3]. Many THMs have been identified as genotoxic mutagens that can be toxic to aquatic animals and even to humans, some of them are carcinogenic. [4] [5]. Therefore, advanced oxidation processes (AOPs) are being researched as sustainable solutions. Human activities and technological developments have led to an increase in emerging pollutants (EP). These compounds can enter our environment from various sources such as active pharmaceutical ingredients and beauty and personal care products and could cause known or suspected adverse ecological on human health effects [6]. Currently, there are no specific emerging pollutants regulations anywhere in the world [7]. However, some efforts have been made to prepare a list of such pollutants; one of them is by the Joint Research Center of the European Commission, which contains more than 2700 materials [8]. Advanced oxidation processes have always attracted the attention of researchers and operators as a suitable process with high efficiency in the last decade. Advanced oxidation processes (AOPs) are characterized by being easy to implement, highly efficient, environmentally compatible, and capable of oxidizing a wide range of contaminants (mineralization to CO_2, H_2O, and inorganic ions). Further, they have been widely applied in refractory contaminant degradation [8]. The methods used in advanced oxidation include ultrasound waves, Fenton, photo-Fenton, ozonation, UV Ozone, UV-persulfate, ultrasonic persulfate, photo catalytic, etc. Among the advantages of these processes, we can mention the production of free radicals with high oxidizing power, high efficiency in the decomposition of organic substances, low start-up, and operating costs, and diversity in methods [9].