Chapter 14
Application of UV-Based Advanced Oxidation Processes in Water and Wastewater Treatment

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ABSTRACT

The presence of hazardous micropollutants in water and wastewater is one of the main concerns in water management system. This micropollutant exists in a low concentration, but there are possible hazards to humans and organisms living in the water. Moreover, its character that is recalcitrant to microbiological degradation makes it difficult to deal with. Advanced oxidation processes (AOPs) are efficient methods to remove low concentration micropollutants. AOPs are a set of processes consisting the production of very reactive oxygen species which able to destroy a wide range of organic compounds. The main principal mechanism in UV-based radical AOP treatment processes is the use ultraviolet light to initiate generation of hydroxyl radicals used to destroy persistent organic pollutants. Therefore, this chapter presents an overview on the principle of radical oxidant species generation and degradation mechanism by various type of UV based AOP in treating contaminants present in water and wastewater. The current application and possible improvement of the technology is also presented in this chapter.

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INTRODUCTION

An escalation of refractory or recalcitrant contaminants in water and wastewater have led to various technologies being developed which includes the use of advanced oxidation processes (AOPs). These processes have shown great potential in treating wide range of pollutants from low to high concentration and has been applied for various types of water treatment such as groundwater (Molnar et al., 2012) wastewater (Babuponnusami & Muthukumar, 2014; Ebrahiem & Mohammednoor, 2017) and landfill leachate (Hassan et al., 2016; Palmer 2016). Photochemical is one of the technology used in AOPs. The technologies have gained more popularity over the past two decades because of its capability to give the dual benefits of contaminants treatment and disinfection (Parsons, 2004). Other than that, the simple and clean operation is also the factor that contributes to the selection of this technology for water and wastewater treatment.

UV irradiation is often used in AOPs since the exposure to the UV-light can enhance oxidizing agents such as hydrogen peroxide (H_2O_2), chlorine and ozone (O_3) to form free radicals (Kumar et al., 2012). Besides that, organic pollutants are oxidized to simpler, less refractory organic compounds or to carbon dioxide, water and mineral acids (Crittenden et al. 2012). Basically, Ultraviolet (UV) based radical AOPs generate powerful oxidizing species such as the hydroxyl radical ($OH^{\bullet}$) by direct photolysis of hydrogen peroxide (H_2O_2), photo-Fenton reactions or heterogeneous photocatalysis. In UV direct photolysis, degradation process through an absorption of incident radiation from the UV light is the main removal mechanism. Therefore, the application usually focusses on the contaminants that strongly absorb UV radiation. On the other hand, UV direct photolysis with H_2O_2 produces OH radical that can remove the contaminants by oxidation processes (Malato et al., 2003). Thus, contaminants in water can be treated by both UV radiation and OH radical induced processed. Most UV light absorber contains double bonds or conjugated double bonds which includes carbon, nitrogen or oxygen atoms and characterized by delocalised π-electrons (Parsons, 2004).

The growing interest in the application of UV-light based in water and wastewater treatment was driven by the concern of potentially carcinogenic and toxic contaminants present in the water and strict regulation set by the water authorities. Consequently, many studies were conducted to explore the UV-light induced degradation of different types of organic and inorganic compounds of environmental concern. OH radical-driven by UV-based AOPs such as photooxidation (UV/O_3, UV/ H_2O_2, UV/O3/ H_2O_2) and photocatalysis (photo-Fenton, UV/ TiO_2) reactions demonstrate significantly larger rates of pollutant removal than those of direct photolysis. This chapter aims to present an overview of the range of UV based radical AOPs available and discuss the principals or fundamentals behind the processes as well as the current applications and opportunities for this treatment to be used in the future.

UV Radiation With H_2O_2 (UV/ H_2O_2)

The basic principle of AOP involves the production of hydroxyl radicals ($OH^{\bullet}$), which can be generated from hydrogen peroxide (H_2O_2) with the presence of ultraviolet (UV) radiation. This process combines H_2O_2 and UV-light in a synergistic effect to degrade organic chemicals and pathogenic microorganisms in aqueous solutions. The generation of hydroxyl radicals are the fundamental to the process as the hydroxyl radicals are largely responsible for the success of this process.