CHAPTER I

INTRODUCTION

Wastewater generated by the textile industries is known to contain considerable amount of non-fixed dyes. The release of the colored wastewater to the ecosystem is a dramatic source of aesthetic pollution, eutrophication and perturbations in the aquatic life. Among the several thousand different dyes and pigments available, azo dyes constitute over 50% of all textile dyes used in the industry. Azo dyes are characterized by nitrogen to nitrogen double bonds, which possess superior fastness to the applied fabric and high photolytic stability [Tang et al., 1995]. Some azo dyes and their degradation products such as aromatic amines are highly carcinogenic. As international environmental standards (ISO 14001, October 1996) are becoming more stringent, technological systems for the removal of organic pollutants such as dyes have been recently developed. Among them, physical methods such as adsorption, biological methods (biodegradation) and chemical methods (chlorination, ozonation), are the most frequently used ones. The traditional processes for treatment of these effluents proven to be insufficient to purify the waste-waters after the different operations of textile dyeing and washing [Lachheb et al., 2002]. Other methods such as coagulation/flocculation, reverse osmosis, and membrane filtration have been utilized. However, these treatment methods only provide separation of the dyes without any dye degradation, creating a waste disposal problem with the large quantities of sludge produced [Tang et al., 2004].

In recent years an alternative to conventional methods, -advanced oxidation processes (AOPs)-is gaining wider acceptance in wastewater treatment applications. AOPs can be successfully used to oxidize many organic pollutants present in aqueous systems via the production and utilization of hydroxyl radicals, which are very powerful oxidants through a multistep process, regardless of different reaction systems used. These radicals show little selectivity towards the attack and are capable of oxidizing various organic pollutants due to their high oxidative capacity (reduction potential of $HO^{\bullet}$ E_o = 2.8 V). Typical AOP processes use ozone, hydrogen peroxide, and UV radiation to generate the hydroxyl radicals. One of the more recent and perhaps more practical methods of producing hydroxyl radicals is the use of UV and suspended catalyst [Al-Bastaki, 2004]. Photocatalytic degradation, involving the use of TiO_2 as catalysts for the production of the hydroxyl radicals, has proven to be an effective method for mineralizing commercial dyes without having any drawbacks mentioned above. Experimental observations indicate almost complete oxidation of most organic compounds to CO_2, water, and inorganic anions via photocatalytic processes. The use of titanium dioxide (TiO_2) as a catalyst for the photo-oxidation of organic compounds has received much interest because TiO_2 is plentiful, inexpensive, powerful and environmentally friendly [Bizani et al., 2006]. Titanium dioxide is a popular and promising material in photocatalytic application due to its strong oxidizing power of its photogenerated holds, high photostability, and redox selectivity [Ohtani et al., 1997]. Titanium dioxide is a wide bandgap semiconductor (3.2 eV), which allows TiO_2 to absorb light with wavelengths shorter than 385 nm. TiO_2 possesses many interesting properties such as transparency to visible light, high refractive index and low absorption coefficient [Wang et al., 1998]. TiO_2 is commercially available and is easy to prepare in the laboratory. The synthesis of TiO_2 includes a number of techniques such as precipitation, chemical vapor deposition, solvothermal method, and glycothermal method. The techniques we used for synthesis of TiO_2 is a sol-gel method. This method can produce nanosized titania at room temperature without consuming a great deal of energy.

Airlift reactor (ALR) is one form of gas-liquid contactor. The configuration of airlift is similar to bubble column in that there are no mechanical devices within the column [Tanthikul et al., 2004]. ALR is an economically and technically significant react system with its simple design and construction. ALR exhibits high efficiency of homogenization and intense mixing for heat and mass transfer, but consumes low amount of power. ALR presents many advantages. The reactor is pneumatically agitated with fluid circulation in a defined cyclic pattern through a loop of conduits. No mechanical agitation is needed. Sufficient aeration can be achieved with low energy input. Excellent contact among the gas–liquid–solid phases can be obtained. Removal or replenishment of solids is easy [Al-Masry et al., 1998; Bentifraouine et al., 1997; Wei et al., 2000; Badino et al., 2001]. Airlift reactors (ALR) are finding increasing applications in chemical industry, biochemical fermentation, and biological wastewater treatment processes [Van Baten et al., 2002].

Typically, degradation of dissolved organic compounds can be conducted in any reactors containing UV-illuminated titania suspended in water. In this work, we combined the benefits of the UV/TiO_2 treatment and the air-lift reactor and employed them for degradation of two dissolved organic dyes, namely, Methylene Blue and Crocein Orange G. Titanium dioxide was synthesized via a sol-gel method and titanium isopropoxide was employed as a precursor. Air-lift reactor used in this study was be designed and constructed. The study included effect of aeration rate, effect of initial concentration of dyes, effect of pH of the solution and effect of diameter of draft tube on performance of photocatalytic degradation of two dyes.

The objectives of this research are as follows:

1. Investigate the reaction kinetics for photocatalytic degradation under UV irradiation of two different dyes, namely, Methylene blue and Crocein Orange G, over titanium dioxide in an air-lift reactor.
2. Investigate effects of the following parameters on the performance of the photocatalytic degradation of two dyes.
    - Aeration rate
    - Initial concentration of dyes
    - pH of the dyes solution
    - draft tube diameter

The thesis is arranged as followed:

Chapter I contains the introduction of this work.

Chapter II presents literature reviews of previous works related to this research.

Chapter III explains basic information about titanium dioxide, principle of a sol-gel method, mechanism of photocatalytic degradation process and basic information about airlift reactor.

Chapter IV describes synthesis of titania a via sol-gel method, characterization equipments and the experimental apparatus and setting.

Chapter V present experimental results and discussion of this research.

Chapter VI presents overall conclusions of this research and recommendations for future research.